

EFFICACY OF ENVIRONMENTAL LABELING: AN ECONOMIC ANALYSIS
WITH TWO EXAMPLES FROM FLORIDA AGRICULTURE

By

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Abstract of Dissertation Presented to the Graduate School
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We evaluated the efficacy of voluntary environmental labeling programs and compiled data on the organic citrus sector in Florida. Using ornamental plants as an example, the theoretical analysis produces conclusions that are relevant for organizations that develop eco-label programs, environmentalists, and policy-makers. An empirical study of organic citrus provides information valuable to citrus growers and handlers, agricultural researchers and extension agents, as well as policy-makers.

First, we developed models of consumer and producer response to voluntary environmental labeling programs. These models draw on economic theory relating to product quality and characteristics, information, and public goods.

Second, we analyzed the potential effectiveness of eco-labeling for protecting the environment under various market conditions. We used a two-product, partial-equilibrium model and a price-endogenous programming model to identify and simulate the effects of eco-labeling on production quantities, land-use, and the

environment. Our analysis provides insight regarding the conditions under which environmental labeling is most effective at protecting the environment and regarding possible unintended consequences of eco-labeling.

Third, we investigated the potential for voluntary eco-label programs to serve as an effective alternative to government-mandated environmental policies. We evaluated efficacy, in terms of environmental effectiveness, Pareto efficiency, cost-effectiveness, and equity. Our analysis identifies several factors that reduce the efficacy of voluntary labeling programs relative to government-mandated environmental policies.

Fourth, we collected primary data on the organic citrus sector, using in-depth and telephone interviews with growers and handlers in Florida. Data include acreage, production volumes, market channels, production practices and costs, grower characteristics, incentives and disincentives for organic production, alternatives, information sources, and research needs. In addition to providing general qualitative and quantitative information on the sector, our study of organic citrus connects to and supports the preceding theoretical analysis, regarding alternative land uses and incentives for adoption of organic certification.

CHAPTER 1 INTRODUCTION

Voluntary certification and labeling programs have proliferated as part of a market-oriented approach to reducing adverse environmental impacts of agriculture and industry. The term “eco-labeling” is commonly used to describe these programs. With a focus on agriculture, we used economic theory and methods to analyze the potential effectiveness of eco-labels at improving environmental outcomes and their efficacy as an environmental policy alternative. An environmental management practice (EMP) label for ornamental plants serves as an example, and a case study of organic citrus in Florida complements the theoretical analysis.

Background on Eco-Labels

What is an eco-label? What are some examples of eco-labels? What characteristics make an eco-label different from other types of labels? What is the general intent or purpose of an eco-label? These questions are addressed in the following sections.

General Description of Eco-Labeling

Environmental labeling programs take various forms. Labeling programs may rely on first-party or third-party verification. Labels may contain positive, negative, or neutral messages. Programs may be mandatory or voluntary. A label may be a seal-of-approval, may verify that a single environmental criterion has been met, may provide a hazard warning, or may disclose information in a report-card format (U.S. EPA 1998). Criteria used for environmental certification and labeling may include a full life-cycle assessment,

or apply only to one stage in the product life-cycle (e.g., production or consumption only). Also, labels may be relevant at different stages of the marketing channel. For example, labels may be intended for retail consumers or for business-to-business transactions.

Our study considers voluntary, third-party verified labeling programs that convey positive messages to the consumer in the form of a seal-of-approval pertaining to the environmental impact of the production process. The label or seal-of-approval is awarded by a third party (governmental or nongovernmental organization) certifying that production of a good meets certain environmental standards. The seal-of-approval implies that the labeled good's production caused less environmental harm than the production of its unlabeled counterpart. This type of eco-label is common for products in agriculture, forestry, and fisheries.

A wide variety of eco-labels can be found in the marketplace for food and fiber, and for all sorts of consumer products. Consumers Union (2003b) describes and evaluates more than 100 different eco-labels found in the United States. The term, eco-label, has evolved to include certification criteria relating to social responsibility, animal welfare, and other consumer concerns besides just environmental impact. Consumers Union (2003a, p. E1) defines eco-labels as "seals or logos indicating that an independent organization has verified that a product meets a set of meaningful and consistent standards for environmental protection and/or social justice." A brief description of selected eco-labels found in agriculture, fisheries, and forestry follows. These include Dolphin Safe, Marine Stewardship Council, Forest Stewardship Council,

Bird Friendly, Fair Trade, Free Farmed, Protected Harvest, The Food Alliance, USDA Organic, and a new eco-label being developed for ornamental plants.

Examples of Eco-Labels

The dolphin safe label found on canned tuna is one of the most widely recognized eco-labels in the United States. According to federal law, tuna labeled as dolphin safe must not be caught by setting nets on dolphin (Teisl, Roe, and Hicks; Consumers Union 2003b). Vessels fishing with purse seine nets in the Eastern Tropical Pacific must have independent observers aboard to verify that nets were not set on dolphin (Teisl, Roe, and Hicks; Consumers Union 2003b). U.S. consumers do not have the choice to buy tuna that is not considered dolphin safe, because the sale of such tuna is restricted by federal laws and embargoes (Teisl, Roe, and Hicks). Essentially a mandatory program, the dolphin safe label does not fit the category of voluntary eco-labeling that is the focus of this dissertation.

The Marine Stewardship Council is a nonprofit organization that certifies fisheries that are not being over fished, have low bycatch or other adverse ecosystem impacts, and have effective management institutions (MSC 2002). Fish products from certified fisheries may bear the MSC logo. Fisheries currently certified by the Marine Stewardship Council include Alaska salmon, Burry Inlet Cockles, Loch Torridon Nephrops, New Zealand Hoki, South West Mackerel handline fishery, Thames Herring, and Western Australian Rock Lobster (MSC 2003). The Marine Stewardship Council label is similar to the type of voluntary label discussed in our study, except that for MSC certification the entire fishery is certified, not individual fishers.

The Forest Stewardship Council is an international organization that certifies wood and wood products from sustainably managed forests (Consumers Union 2003b).

Certification criteria include social and economic impacts as well as environmental impacts of the forest industry (Consumers Union 2003b; FSCUS). Specific principles include protection of biodiversity, water resources, and forest ecosystem functions; promotion of community economic well-being; and respect for workers' rights and indigenous peoples' rights (FSCUS). Products that meet its certification requirements may use the FSC label.

A variety of shade-grown or bird-friendly coffee labels exist. One such eco-label is the Smithsonian Migratory Bird Center's Bird Friendly coffee label. Many species of song birds found in North America migrate to Central and South American coffee-growing regions during the winter months. Whereas coffee often is grown on unshaded, monoculture plantations that reduce bird habitat, bird-friendly certification recognizes traditional coffee farms that maintain a tree canopy or other aspects of bird habitat. (Consumers Union 2003b; Gobbi; Smithsonian Migratory Bird Center).

The Fair Trade label applies primarily to social responsibility and equitable trading practices, but considers environmental impact as well. The nonprofit organization TransFair USA, a member of Fair Trade Labeling Organizations International, certifies and promotes Fair Trade products, including coffee, tea, and cocoa. It works to achieve a "fair deal for farmers and workers, environmental sustainability, and profitability for all parties in the chain of production" (TransFair USA: E1). The Fair Trade certification for coffee requires that importers purchase directly from certified cooperatives of small-scale producers at a minimum floor price and extend credit to the producers if requested. It encourages democratic, cooperative production, environmental protection, and long-term,

stable, trading relationships (TransFair USA). Different from most other eco-labels, it is a “social” label, and it pertains to buyer and seller relationships in the marketing channel.

The Free Farmed label represents an animal welfare standard for meat and dairy production. Administered by Farm Animal Services (founded by the American Humane Association), the program certifies farms that meet guidelines pertaining to the humane treatment of animals. Criteria include food and water access and quality, comfortable living conditions, and animal health (Consumers Union 2003b). This label pertains to an ethical issue that concerns a segment of consumers.

Protected Harvest is an integrated pest management (IPM) certification program first developed for Wisconsin potatoes. Intended to reduce the amount and toxicity of pesticides used in potato production and provide recognition of this in the marketplace, Protected Harvest guidelines were designed by a collaborative effort of The World Wildlife Fund, the University of Wisconsin, the Wisconsin Potato and Vegetable Growers Association, and other organizations. Protected Harvest is now an independent certification organization. Certification criteria are based on a point system pertaining to pest management practices and pesticide use. Certified potatoes are sold at retail displaying the Protected Harvest seal-of-approval (Consumers Union 2003b; Protected Harvest; WWF).

The Food Alliance program certifies fruit, vegetable, and livestock farms with “environmentally and socially responsible management practices” (The Food Alliance: E1). The Food Alliance is a nonprofit organization formed by “farmers, consumers, scientists, grocers, processors, distributors, farm worker representatives and environmentalists” (Consumers Union 2003b: E1). The Food Alliance standard prohibits

the use of genetically engineered seed or livestock, and prohibits the routine use of antibiotics and hormones. Its certification criteria measure performance in the areas of pest management, soil and water conservation, working conditions, and wildlife habitat conservation (The Food Alliance). Food products from certified farms may display The Food Alliance-Approved logo.

The U.S. Department of Agriculture (USDA) National Organic Program was developed under a mandate from the Organic Foods Production Act of 1990. A national organic standard was published in the Federal Register on December 21, 2000. Full implementation of organic production, handling, and marketing regulations went into effect on October 21, 2002. After this date, use of the USDA organic seal was allowed on products containing at least 95% organic ingredients (USDA-AMS 2003a and 2003b; USDA-OC). According to the National Organic Standard, an organic production system is one that integrates “cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity” (USDA-AMS 2002). The National Organic Standard contains a list of allowed and prohibited substances, land-use and record-keeping requirements, and guidelines for soil fertility and pest management. The use of most synthetic chemicals and conventional pesticides, antibiotics and growth hormones, genetic engineering, sewage sludge, and irradiation is prohibited in organic agriculture. Product handling and processing guidelines are contained in the national standards as well (USDA-AMS 2002 and 2003a; USDA-OC). Organic farms and handling operations that wish to label their products as organic, and use the USDA organic seal, must be certified by USDA-accredited certifying agents (USDA-AMS 2003c). Although use of the USDA organic seal (as well as the word

organic) is regulated by federal law, organic labeling is still voluntary, in the sense that producers have the choice of whether to adhere to organic standards, or not; and consumers have the choice of purchasing certified organic products, or those that are not.

A new eco-label proposed for Florida's ornamental plant nursery industry is based on certification of environmental management practices. "The state of Florida is the second largest producer of ornamental plants in the United States" (Hodges and Haydu, p.1), and the ornamental plant industry is "the second largest agricultural sector in Florida" (Larson Vasquez and Nesheim, p.1). Large amounts of pesticides and fertilizers are used in the industry, posing contamination risks for Florida's water resources and associated negative impacts on wildlife and human health (Leppla; Hodges, Aerts, and Neal; Larson Vasquez and Nesheim; Stamps). Integrated pest management (IPM) and best management practice (BMP) guidelines have been developed for the sector (Mizell and Short; Stamps). These guidelines promote scouting and monitoring, cultural and biological practices, and more efficient use of water and chemical inputs, to reduce unnecessary applications and minimize the risk of negative environmental impacts. Although a first stage in the development of this certification and labeling program focuses on IPM for woody ornamentals, the ultimate goal is to expand the scope of certification to include other nursery and ornamental crops and "additional criteria of public concern, including wildlife and habitat preservation, farm worker safety, and BMPs for nutrient and water resource management" (Leppla, p.3). In our study, these practices are referred to collectively as environmental management practices (EMPs). The leatherleaf fern, an ornamental plant produced in Florida, is used as an example in chapters that follow.

Our study focused on voluntary, environmental labels on retail products that present positive information in the form of a seal-of-approval indicating that an independent (third-party) organization has certified a product's production as adhering to established EMPs. The Forest Stewardship Council, bird-friendly, Protected Harvest, Food Alliance, and USDA Organic labels, as well as the new certification and labeling program being developed for ornamental plants, are good examples of the type of label emphasized in our study. In particular, we refer to the EMP program (for ornamental plants) and to the USDA organic program.

Special Characteristics of an Eco-Label

Eco-labels that are used voluntarily (to present positive information in the form of a third-party verified seal-of-approval pertaining to the environmental impact of the production process) are different than most other labels found on food and consumer products. Two key characteristics make eco-labels unique.

First, an eco-label conveys information about the production of a good, but not necessarily about the product itself. For example, Alaska salmon certified by the Marine Stewardship Council may be indistinguishable from salmon caught in an uncertified fishery, except that the certified salmon displays the MSC logo on the package or at the retail counter. The physical attributes of the salmon product (such as appearance, texture, freshness, nutritional content, and eating quality) may be essentially the same. Likewise, there may be no physical difference between uncertified wood and wood that has been certified by the Forest Stewardship Council. The certification and label apply only to the environmental impact of the harvesting process, and the sustainable management of the resource.

Second, an eco-label informs consumers about a public attribute (environmental impact) tied to a private good. A public good is often defined as a good that is nonexcludable and nonrival. That is, once a public good is provided to (or by) one individual, others can enjoy the benefits of the good (because it is difficult or costly to exclude others). Also, if one individual enjoys or appreciates the benefits or services provided by a public good, it does not reduce the benefits or services available to others. For example, benefits from the purchase of dolphin-safe tuna (avoiding contributing to dolphin mortality) accrue in a marginal sense not only to the individual consumer but to all those who are concerned about the killing of dolphin. Similarly, everyone who enjoys birds that migrate to coffee-growing regions is affected marginally by one individual's choice of bird-friendly vs. uncertified coffee. Whereas most product labels inform the consumer about private attributes—those that only directly and immediately affect the consumer of the good (nutrition, safety, horsepower, etc.)—an eco-label informs the consumer about public attributes (environmental impacts that can affect numerous people). Although the product itself (e.g., a bag of coffee, a piece of fish, or a grapefruit) is a private good, the eco-label signifies a public attribute associated with the production of the private good.

Some eco-labels signal information about both public and private attributes. For example, organic and pesticide-free labels inform consumers about the environmental impact of production (a public attribute), and also about the likelihood of pesticide residues (a private attribute) on the product. The theoretical analysis presented in subsequent chapters focuses on eco-labels whose significance to the consumer primarily pertains to a public attribute.

Intentions behind Eco-Labeling

Various stakeholders bring assorted perspectives on the purpose behind any eco-labeling program. For example, consumers, producers, and environmental groups, may support eco-labeling in pursuit of different, though interrelated, objectives.

For consumers, the introduction of an eco-label provides additional information that was not previously available or readily accessible. In some cases, an eco-label may introduce a new claim about a product that had not previously been made. The introduction of a meaningful eco-label allows consumers who are aware of and concerned about the environmental impact of production to adjust their purchasing behavior in a way that more accurately reflects their values and preferences, without incurring high search costs. By providing more information and additional choices, an eco-label enables consumers to obtain greater satisfaction from their purchases in the marketplace.

In other cases, an eco-label serves to verify claims that have already been made about certain products. In this sense, an eco-label increases the credibility of an environmental claim, especially when the certification and labeling program is supported by a trusted third-party organization. For example, Consumers Union (2003b) has documented numerous claims that are misleading or relatively meaningless, such as “environmentally friendly” or “free range.” A clear and meaningful eco-label, however, provides the consumer with better information than generic claims provided by the product’s manufacturer. Consumers Union expresses the opinion that before implementation of the national organic standards, “unregulated use of the term ‘organic’ was leading to at best confusion, and at worst fraud” (Consumers Union 2001: E1). Uniform guidelines for what constitutes organic agriculture, and a standardized label under the National Organic Program, thus served to clarify and improve trust in the

“organic” claim. For consumers, eco-labels reduce the costs of searching for information about impacts of production, improve the credibility of environmental claims, reduce uncertainty about product attributes, and provide additional product choices. A major eco-labeling objective for consumers is the reduction in search costs and provision of better, more credible information about product attributes.

Producers of goods also can benefit from eco-labeling programs. Profit-maximization is an important objective for producers, although other objectives may also enter their decision-making process. Eco-labels enable producers who generate environmental benefits to differentiate their products in the market and to potentially obtain higher prices and higher returns. In addition to the incentives created by price premiums for eco-labeled products, producers may be motivated to adopt environmental certification because of a reduced risk of liability for environmental damage, improved public relations, and possibly lower production costs (Henriques and Sadorsky; Khanna and Damon; Khanna and Anton; Leppla; WWF). Producer groups pursue eco-labeling schemes as a means to improve profits or satisfy other objectives.

Environmental groups support eco-labels as a means to reduce the environmental impacts associated with production, and thus improve environmental quality. When consumers choose eco-labeled products, they reward producers who practice environmental stewardship. Consumers who purchase eco-labeled products (often at a premium) help keep environmentally certified producers in business and create incentives for other producers to adopt certified practices. Thus, eco-labels have the potential to improve environmental outcomes associated with market interactions. From the

perspective of environmental groups, and nonprofit organizations that develop eco-labeling programs, environmental protection is the primary objective.

Research Questions and Objectives

A policy analyst would ask whether a particular policy or program effectively meets policy objectives as defined by the stakeholders or decision-makers. Economists often contribute to policy analysis by evaluating the economic efficiency of a policy. An evaluation of economic efficiency might involve an analysis of costs and benefits, based on the notion of Pareto efficiency, or an analysis of the cost-effectiveness at meeting a particular policy objective. Economists also can contribute to policy analysis by assessing the distributional effects or equity of a policy. In any case, an evaluation of the likely consequences of a policy or program is an essential first step, on which to base further evaluation in terms of efficiency or equity.

Our study focused on the objective of environmental protection and assessed the likely consequences of eco-labeling in terms of environmental impacts under different market conditions. An understanding of consumer and producer behavior is necessary for analyzing market responses and ultimately the environmental impact of eco-labeling. We presented models of consumer and producer decisions regarding environmental certification and labeling. A two-product, partial equilibrium model and a price-endogenous programming model were used to assess the potential effects on production, land-use, and the environment. We extended our analysis of the efficacy of environmental labeling to include environmental effectiveness, Pareto efficiency, cost-effectiveness, and equity. The theoretical analysis relies on the example of an EMP label for ornamental plants (leatherleaf ferns) to add concreteness, and a case study of the

Florida organic citrus sector complements the theoretical analysis. The rest of this dissertation is organized as follows.

In Chapter 2, we review literature and present a model of consumer behavior in response to eco-labels. Branches of consumer theory pertaining to product characteristics and quality, information, and impure public goods are examined. Using a product characteristics approach, our consumer model provides a basis for predicting consumer demand response to eco-labeling.

In Chapter 3, we review literature and present a model of producer response to certification and labeling programs. The literature review focused on theories of producer choice of product quality, advertising, and technology adoption, and summarizes empirical studies of producer decisions regarding environmental management, certification, and labeling. Our producer model considers three separate decisions pertaining to adoption of environmental management practices, certification, and marketing products with an eco-label.

In Chapter 4, we introduce two theoretical models used to identify market interaction effects and the potential impact of eco-labeling on the environment. We used a two-product, partial-equilibrium model and a price-endogenous programming model to address the following research questions: Under what conditions are eco-labels most effective at achieving the objective of environmental protection? Under what conditions are eco-labels least effective at protecting the environment? Is it possible that an eco-labeling program could actually increase environmentally harmful production? Our analysis provides a framework for anticipating the effects of eco-labeling on production, land-use, and the environment under different market conditions.

In Chapter 5, we evaluate the efficacy of voluntary environmental labeling as a potential alternative to government-mandated environmental policies. Specifically we addressed the research question: What are the implications, in terms of environmental effectiveness, Pareto efficiency, cost-effectiveness, and equity, of relying on voluntary environmental labeling programs as an alternative to government-mandated environmental policies?

In Chapter 6, we present a case study on organic citrus, based on in-person and telephone interviews with growers and handlers in Florida. The case study provides information on Florida organic-citrus acreage and market outlets, production volumes, grove-care practices and costs, grower characteristics, incentives and disincentives for organic citrus production, and research needs.

In Chapter 7, we synthesize the case study results with the preceding theoretical analyses. We draw final conclusions and suggest avenues for further research.

CHAPTER 2

CONSUMER DEMAND RESPONSES TO ECO-LABELS

An understanding of the effects of introducing an eco-label on consumer demand is essential for analyzing the efficacy of eco-labeling. In this chapter, we review literature and introduce a model that provides a framework for anticipating consumer demand responses to eco-labels.

Literature Review

Although there is no well-developed theory of consumer response to labeling, several branches of consumer theory relate to this concept. An eco-label provides additional information to consumers, changing their perception of a product's characteristics. Furthermore, an eco-labeled product is an impure public good. Theories of product characteristics, information, and impure public goods are reviewed and synthesized next as a basis for a model of consumer response to eco-labeling. We also describe an existing consumer eco-label model found in the literature.

Many empirical studies evaluate actual consumer responses to specific environmental labels. We reviewed several empirical studies that used a variety of techniques to assess consumer demand for eco-labeled products.

Product Characteristics and Quality in Consumer Theory

Lancaster, Becker, Muth, and Gorman are credited with developing a theory of the consumer based on product characteristics, although the origins of the theory can be traced back farther. Also known as household production theory, market goods are purchased for the characteristics that they produce (often in combination with other

market goods or time and labor inputs). Literature on the characteristics approach to consumer theory is summarized next. Notation is altered to provide consistency.

In a classic paper, Gorman introduces a consumer model based on product quality characteristics, specifically relating to the egg market. In his model, a consumer's utility function is defined over the various characteristics of eggs and quantities of all other goods. Gorman's consumer problem is

$$(2-1) \quad \begin{aligned} \text{Max } U &= U\left(\sum_j Z_j; \sum_k Y_k\right) \\ \text{s.t.} \quad Z_j &= \sum_i a_{ij} q_i \\ \sum_i p_i q_i + \sum_k p_k Y_k &= I \end{aligned}$$

where Z_j is the amount of characteristic j (e.g., vitamin A) consumed; Y_k are the quantities of other goods consumed; q_i is the quantity of egg type i purchased; a_{ij} is the amount of characteristic j contained in egg i ; p_i and p_k represent the market prices of eggs and all other goods; and I is the consumer's money income. Important assumptions in his model are that characteristics are measurable quantities, and that the total amount of a characteristic consumed is the sum of the amounts contained in the eggs. Gorman's model represents inputs (goods) that have constant marginal rates of technical substitution in the production of outputs (characteristics), and considers joint products (multiple characteristics) from a single input.

The necessary first-order condition for utility maximization in the Gorman model is

$$(2-2) \quad \begin{aligned} p_i &= \left(a_{i1} \frac{\partial U}{\partial Z_1} + a_{i2} \frac{\partial U}{\partial Z_2} + \dots \right) / \lambda \\ p_i &= a_{i1} \pi_1 + a_{i2} \pi_2 + \dots \end{aligned}$$

where λ is the marginal utility of income, and π_j is the imputed price for characteristic j .¹ The market price for egg type i is the sum of the imputed prices for characteristics times the input-output coefficients.

Muth introduces a similar model, in which “[goods] purchased on the market by consumers are inputs into the production of [characteristics] within the household”

(p.699). The consumer problem according to Muth’s model is

$$(2-3) \quad \begin{aligned} \text{Max } U &= U(Z_1, \dots, Z_j) \\ \text{s.t.} \quad Z_j &= Z_j(q_1, \dots, q_n) \\ p_1 q_1 + \dots + p_n q_n &= I \end{aligned}$$

He demonstrates that the marginal rate of substitution (MRS) between two market goods used to produce the same characteristic reduces to

$$(2-4) \quad \frac{\partial Z_j / \partial q_1}{\partial Z_j / \partial q_2}$$

The MRS between the two market goods equals the marginal rate of technical substitution (MRTS) in production of characteristic j (Muth). If the production function were defined as in the Gorman model, the MRS would be the constant ratio of input-output coefficients, a_{1j}/a_{2j} . Muth notes that the MRS between two market goods used to produce the same characteristic j “is functionally independent of all [goods] not used in the production of [characteristic j] by the household” (p.701). He does not consider the case of joint products, in which one market good produces multiple characteristics.

Lancaster (1966a, 1966b, 1991) developed a detailed linear characteristics model. His basic consumer model is similar to Gorman’s. In Lancaster’s model, a consumer

¹ In Gorman’s paper, λ is incorrectly placed in the numerator on the right-hand side of the equation.

maximizes utility, which is defined over product characteristics, subject to a budget constraint defined in goods-space and a consumption technology constraint that transforms the market goods into characteristics-space. Lancaster specifies the consumer problem as

$$(2-5) \quad \text{Max} U(z)$$

$$\text{s.t.} \quad \begin{aligned} pq &\leq I \\ z &= Bq \end{aligned}$$

where z and q are vectors of characteristics and market goods respectively; and B is a matrix of input-output coefficients transforming goods space to characteristics space.

According to Lancaster (1966a, p.139)

A consumer's complete choice subject to a budget constraint...can be considered as consisting of two parts:

- a) An efficiency choice, determining the characteristics frontier and the associated efficient goods collections.
- b) A private choice, determining which point on the characteristics frontier is preferred by him.

An important assumption in Lancaster's approach is that the consumption technology (defined by the input-output coefficients in the linear model) is objectively determined, independent of the consumer's perception or preferences. That is, every consumer faces the same characteristics frontier. A change in product quality, or introducing a new good with a different mix of characteristics, affects the shape of the characteristics frontier (Lancaster 1966a). This induces a change in the efficient bundle of goods without changing consumer preferences.

The change in the slope of the frontier is analogous to the change in the budget line slope in the traditional case and, with a convex preference function, will result in a substitution of one characteristics bundle for another and, hence, of one goods bundle for another (Lancaster 1966a, p.143).

Lancaster asserts that his model allows one to predict the result of introducing a new product or a differentiated product better than the traditional consumer theory does.

Hendler provides a critique of Lancaster's approach. He faults Lancaster for ignoring the possibility of characteristics with negative utility. Also, Hendler (p.197) points out two restrictive assumptions in Lancaster's model: a) "utility independence of characteristics per consumption unit", and b) "the mixability of goods per consumption unit." Hendler argues that it is unrealistic to compare the utility of characteristics obtained from a linear combination of two goods with the characteristics contained in a single good.

Michael and Becker pose a household production function approach similar to the one described by Muth. Their production function is $Z_j = z_j(q_j, t; E)$, where q_j represents market goods, t is a household's time, and " E is a vector of variables which represents the environment in which the production takes place" (p. 382). According to Michael and Becker, the necessary first-order conditions for maximization of utility defined over the characteristics Z_j imply that marginal rates of substitution between characteristics are

$$(2-6) \quad \frac{U_{z1}}{U_{z2}} = \frac{w(\partial t / \partial z_1) + p_1(\partial q_1 / \partial z_1)}{w(\partial t / \partial z_2) + p_1(\partial q_1 / \partial z_2)} = \frac{\pi_1}{\pi_2}$$

where U_{zj} is the marginal utility with respect to characteristic Z_j , w is the wage rate (value of household's time), and π_1 and π_2 are the implicit "shadow" prices of characteristics 1 and 2. We note that Michael and Becker's first-order condition (Eq. 2-6) is correct only for the case of fixed-proportions production, but is incorrect for a generic variable-proportions production function. They define the MRS between market goods as

$$(2-7) \quad \frac{U_{q1}}{U_{q2}} = \frac{U_{z1}MP_{11}}{U_{z2}MP_{22}} = \frac{p_1}{p_2}$$

where MP is marginal product. We note that Eq. 2-7 is correct for a variable-proportions production function, but does not apply to the fixed-proportions case. Michael and Becker point out that if both inputs are used to produce the same final characteristic, then the condition (Eq. 2-7) is simply that the ratio of marginal products equals the (input) price ratio. This result is similar to the one obtained by Muth. Michael and Becker note that the case of joint products (one market good producing multiple characteristics) implies that the marginal value of a good is

$$(2-8) \quad \sum U_{z_j} MP_{1j} = p_1$$

“In general, the price of any [characteristic] is then affected by the level of output of the other [characteristics] which use [the same input]” (Michael and Becker, p. 383).

Hedonic price theory distinguishes a product and its market value by the product's characteristics. Rosen (p. 34) defines hedonic prices as “implicit prices of attributes...revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them.” He describes a consumer's value or bid function for product attributes as “the expenditure a consumer is willing to pay for alternative [levels of characteristics] at a given utility index and income” (Rosen, p. 38).

In Rosen's expanded model, the consumer chooses the quantity of a good to purchase and chooses the level of characteristics associated with the good. The consumer's problem is to maximize a utility function, $U(y, z_1, \dots, z_n, q)$, subject to the budget constraint, $I = y + qp(z)$, where q is the quantity of the good, $z_1, \dots, z_n$ is the bundle of characteristics associated with the good, y is all other goods consumed, I is income,

and $p(z)$ is the good's price as a function of the characteristics vector. In Rosen's model, necessary first-order conditions imply that

$$(2-9) \quad \frac{U_q}{U_y} = p(z)$$

and

$$(2-10) \quad \frac{U_{zi}}{U_y} = qp_i(z).$$

Equation 2-9 is the familiar condition that marginal rate of substitution should equal the price ratio. Equation 2-10 demonstrates that the level of characteristic (or product quality) should be chosen so that the marginal rate of substitution for quality with respect to income (a consumer's value function for the characteristic) equals the rate at which price increases with quality, p_i , times the optimal quantity of the good. Rosen acknowledges that this model restricts the consumer to purchasing only one type of good.

Ladd and Suvannunt present a consumer model in which utility is defined over characteristics (Z_j) embodied in multiple goods and characteristics (X_i) unique to one good only. Similar to the results from Gorman and Michael and Becker, the necessary first-order conditions of the Ladd and Suvannunt model are

$$(2-11) \quad p_i = \sum_j \frac{\partial Z_j}{\partial q_i} \left[\frac{\partial U / \partial Z_j}{\partial U / \partial I} \right] + \frac{\partial X_i}{\partial q_i} \left[\frac{\partial U / \partial X_i}{\partial U / \partial I} \right],$$

where X_i is the characteristic unique to product i . Noting that income equals expenditure, the authors convert the first-order conditions to

$$(2-12) \quad p_i = \sum_j \frac{\partial Z_j}{\partial q_i} \frac{\partial E}{\partial Z_j} + \frac{\partial E}{\partial X_i},$$

where E is total expenditure, and $\partial E / \partial Z_j$ is “the (marginal) implicit or imputed price paid for the j th product characteristic” (Ladd and Suvannunt, p. 505). They conclude that

for each product consumed, the price paid by the consumer equals the sum of the marginal monetary values of the product’s characteristics; the marginal monetary value of each characteristic equals the quantity of the characteristic obtained from the marginal unit of the product consumed multiplied by the marginal implicit price of the characteristic (Ladd and Suvannunt, p. 504).

Equation 2-12 is very similar to Eq. 2-2 from Gorman and Eq. 2-8 from Michael and Becker. Ladd and Suvannunt test the hypotheses of their model empirically using nutritional elements of food items and obtain significant results.

Stigler and Becker (p. 76) argue “that tastes neither change capriciously nor differ importantly between people.” The authors advocate a characteristics approach to consumer theory and explain the effect of advertising or social influences as changing household production constraints not as changing consumers’ preferences. They present a consumer model in which utility is defined over characteristics Z_j and the household production function is $Z = f(q, A, E, V)$, where q is the quantity of a market good, A is the advertising for the market good, E is a human capital variable affecting production, and V is a vector of other relevant variables. If the characteristic output, Z , is assumed proportional to the amount of market good consumed, q , for any given level of A , E , and V , Stigler and Becker’s production function becomes

$$(2-13) \quad Z = g(A, E, V)q.$$

This relationship is similar to the second constraint in Eq. 2-5 and the linear characteristics models of Lancaster and Gorman, except that the coefficient $g(.)$ is not the same for every household. In Stigler and Becker’s model, the coefficient $g(.)$ varies according to household characteristics and advertising exposure. In particular,

$\partial g / \partial A > 0$. Thus, the relationship between shadow prices of characteristics and market prices of goods, as in Eqs. 2-2, 2-6, 2-8, and 2-12, for a single market good and a single characteristic is

$$(2-14) \quad \pi_z = \frac{p}{g(\cdot)}.$$

For a given market price p , an increase in g will lower the characteristics shadow price π_z . According to Stigler and Becker, an increase in g allows a household to obtain more of the characteristic from a unit of market good, implying that a unit of characteristic becomes less expensive. Stigler and Becker (p. 84) describe the relationship between advertising and the demand for characteristics and market goods as follows:

An increase in advertising may lower the [characteristic] price to the household (by raising g), and thereby increase its demand for the [characteristic] and change its demand for the firm's output, because the household is made to believe—correctly or incorrectly—that it gets a greater output of the [characteristic] from a given input of the advertised product. Consequently, advertising affects consumption in this formulation not by changing tastes, but by changing prices. That is, a movement along a stable demand curve for commodities is seen as generating the apparently unstable demand curves of market goods and other inputs.

Whereas Lancaster emphasizes that the consumption technology is objectively measurable and the same for all consumers, Stigler and Becker relax this assumption. They allow the coefficient, g , to vary with household attributes and perceptions influenced by advertising.

Deaton and Muellbauer acknowledge some benefits associated with the Stigler and Becker approach. They question the usefulness, however, when characteristics are qualitative in nature (i.e., not easily observable or measurable). Deaton and Muellbauer (p. 244) state

Our only qualm is that, when the intervening variables are not observable, there may be little cutting edge to the distinction between preferences and constraints,

and the ‘explanations’ offered by the approach can sometimes be complicated ways of making rather simple points.

Deaton and Muellbauer point out other shortcomings of the linear characteristics models, such as the problem of corner solutions, in which a consumer’s optimal bundle is obtained from fewer goods than there are characteristics. In this case, the marginal rate of substitution between characteristics does not equal the shadow price ratio (Deaton and Muellbauer). The authors suggest a discrete choice formulation of the consumer problem to deal with corner solutions. “When households choose between two discrete alternatives, the relevant measure of demand to be empirically explained is the probability of choosing one or the other” (Deaton and Muellbauer, p. 267).

Tirole explains the consumer’s problem in a vertically differentiated market as a discrete choice of whether to purchase or not at a given quality level. A taste parameter θ describes a consumer’s willingness to pay for a quality level z , such that the consumer will purchase a good only if $\theta_z > 0$. A distribution function can be estimated for consumers in a market, such that “ $F(\theta)$ is the fraction of consumers with a taste parameter of less than θ ” (Tirole, p.97). The taste parameter, θ , can be interpreted as the individual’s marginal rate of substitution between the quality characteristic and income, $\partial U_z / \partial U_y$. The individual consumer will purchase a market good if $\theta > p/g$, where p is the market price and g represents the quality index. Tirole’s model is similar to Eq. 2-14 and Stigler and Becker’s description of g as the amount of a characteristic contained in the market good. The distribution function, $F(\theta)$ can be converted to a demand function of the form

$$(2-15) \quad D(p) = N[1 - F(p/g)],$$

where $D(p)$ is quantity demanded at a given quality level, and N is the number of consumers in the market (Tirole). This formulation assumes unit demands, but could be adjusted to account for differences in quantity demanded among consumers. It is clear from Tirole's formulation that an increase in the quality index g will increase the quantity demanded at any given price. While this approach is appropriate for modeling the discrete choice of buying one market good, it does not provide insight as to the relationship between demands for various market goods.

Information and Uncertainty in Consumer Decisions

Lancaster (1966b) suggests that consumers may not act efficiently, if they are unaware that a particular good possesses certain characteristics or if they are uncertain about these characteristics. In Lancaster's model, the efficient characteristics frontier is the same for all consumers. This idea provides the basis for his "argument in favor of public information on these matters and in favor of legal requirements, such as composition and contents labeling, designed to increase knowledge of the available consumption technology" (Lancaster 1966b, p.18-19).

Akerlof demonstrates that quality uncertainty or asymmetrical information can undermine markets for high quality products. Asymmetrical information occurs when one party to a transaction is less well informed than the other party. In Akerlof's example of the market for used cars, sellers have much more information about the quality of the automobile than do potential buyers. Akerlof's hypothesis is summarized as follows. If buyers cannot tell the difference between a good car and a "lemon" prior to purchase, they would only be willing to pay a value reflecting their estimate of the average quality of cars on the market. It is not likely, however, that owners of high quality cars would be willing to sell at the average quality price. Thus, only low quality

cars would be sold at the going price. If buyers come to realize this, they may adjust their estimate of the average quality of cars on the market and their willingness to pay downward once again, further reducing the incentive for high quality cars to be sold. In short, if quality cannot be credibly conveyed, consumers will not pay extra for uncertain quality, and there will be no incentive for producers to supply quality products.

Product attributes may be classified according to how easily the attributes can be verified by consumers. According to Nelson, search attributes are characteristics of a product that consumers can easily identify before purchase, whereas experience attributes can only be verified by consumers after they use the product. Darby and Karni describe a third category, called credence attributes, which are unobservable to consumers even after purchase and consumption. Credence attributes are especially vulnerable to problems of asymmetric information and adverse selection, which erode incentives to supply these attributes.

The environmental impact of a good's production is information that cannot be verified easily by most consumers even after consumption. The environmental characteristics embodied in a product are therefore considered credence attributes. According to McCluskey, third-party monitoring is necessary for most producers to have incentive to provide high-quality credence goods, such as environmentally friendly food products. Using laboratory markets for products making environmental claims, Cason and Gangadharan (p. 129) find that "unverified claims are not sufficient to improve market outcomes." The results of their experiment suggest that certification by an independent organization is essential for the market to improve the environmental quality of goods. Teisl, Roe, and Levy test the response of survey participants when presented

with different types of eco-labels. Respondents gave significantly different credibility scores depending on the label format, detail, and certifying organization (Teisl, Roe, and Levy).

Consumer choice under uncertainty also can be modeled according to the concept of expected utility (Nicholson). If subjective probabilities are assigned to uncertain outcomes 1 and 2, then expected utility is the probability of outcome 1 times its utility plus the probability of outcome 2 times its utility. The expected utility approach can be applied to consumer choice when product quality is uncertain. Consider a consumer who obtains known utility, U_0 , from a product without an environmental attribute, and utility, U_1 , from a product with an environmental attribute. Let the consumer assign probability, p , that an environmental claim is true, and probability $1-p$ that it is false. The consumer's expected utility is $pU_1 + (1-p)U_0$. Consumers will make choices so as to maximize their expected utility if they "obey the von Neumann-Morgenstern axioms of behavior in uncertain situations" (Nicholson, p. 218).

By lowering search costs, eco-labels serve to reduce information asymmetry and consumer uncertainty about credence attributes associated with the environmental impact of the production process. Some eco-labels are more effective than others at boosting consumer confidence in the credibility of environmental claims. The introduction of an eco-label on an existing product can be modeled as an increase in the probability consumers place on the environmental quality claim being true. Assuming linear utility, the effect is the same as increasing g in the Stigler and Becker, and Tirole models, essentially increasing the expected amount of the environmental characteristic provided by the market good.

Theory of Impure Public Goods

An eco-labeled product is similar to an impure public good (i.e., a market good that contains both private and public attributes). For example, the consumer of bird-friendly coffee receives a private benefit, the cup of coffee, and also the satisfaction of contributing to a public benefit, preserving bird habitat. Alternatively the unlabeled product could be considered an impure public bad (i.e., a market good that contains a private benefit, but reduces the welfare of others). For example, if conventional agricultural production contributes to the contamination of local water supplies (through fertilizer and pesticide runoff), then its products contain both a private benefit for the consumer (food) and a public bad associated with harmful impact of production. An EMP label for Florida leatherleaf ferns, however, informs consumers that production followed management practices that protect water quality, avoiding the public bad associated with uncertified production.

Cornes and Sandler (1984, 1994, 1996) model consumer behavior in relation to impure public goods and bads. In their basic model, a consumer chooses quantities of a numeraire good and a market good that generates a private and public characteristic. The total quantity of the public characteristic enjoyed by the consumer depends also on the actions of others. The Cornes and Sandler consumer problem is

$$(2-16) \quad \underset{Y, q_1}{\text{Max}} U = U(Y_1, Y_2, Y_3)$$

$$\begin{aligned} & Y_1 + pq = I \\ \text{s.t.} \quad & Y_2 = \beta q \\ & Y_3 = Y_3^0 + \gamma q \end{aligned}$$

where Y_1 is the numeraire characteristic representing all other goods; Y_2 is the private characteristic generated from consumption of the market good q ; and Y_3 is the total level

of the public good enjoyed by the consumer (Cornes and Sandler 1994, p.406; 1996, p.256). The characteristic Y_2 is a function of the quantity of market good q , and Y_3 is a function of the level of public good provided by others, Y_3^0 , and the individual's contribution through purchases of market good q .

Necessary first-order conditions for utility maximization in the Cornes and Sandler consumer model imply that

$$(2-17) \quad p = \beta \frac{U_2}{U_1} + \gamma \frac{U_3}{U_1}$$

$$p = \beta \pi_2 + \gamma \pi_3$$

where U_i is marginal utility, and π_i is the shadow value of the characteristic to the individual. This condition is similar to Eqs. 2-2, 2-8, and 2-12. Taking the contribution of others as given and acting only in self-interest, the individual consumer does not consider the public good value to others resulting from private consumption choices.

The Cornes and Sandler model of impure public goods is not entirely suitable for the case of voluntary eco-labeling, because only one good provides the joint public and private characteristics. With voluntary eco-labeling, consumers typically have the choice of purchasing two or more similar products, each providing the same private and public attributes to different degrees.

Prior Model of Eco-Labeling

Van Ravenswaay and Blend formulate a consumer model of the choice between an unlabeled and eco-labeled product. Their basic consumer model is

$$(2-18) \quad \text{Max} U(X, X', Q(X, X', E))$$

$$s.t. \quad PX + P'X' = M$$

where “ X is the quantity of goods purchased, Q is environmental quality, E is an exogenous amount of environmental damage, P is the price of X , and M is income....Let X' be the quantity purchased of the ecolabeled version of X ” (Van Ravenswaay and Blend, p. 124). The authors identify the condition for a consumer to choose the unlabeled product X over the unlabeled product X' as

$$(2-19) \quad P' - P > \frac{\partial U / \partial Q [\partial Q / \partial X' - \partial Q / \partial X]}{\lambda}$$

Equation 2-19 demonstrates that a consumer will not purchase an eco-labeled product if the price premium exceeds the marginal rate of substitution between environmental quality and income times the difference in environmental impact between the two products.

In another version of the model, van Ravenswaay and Blend introduce a probability variable representing consumer trust in an eco-label claim. The model is formulated as

$$(2-20) \quad \text{Max} U(X, X', (Q(X, X', E) \text{Prob}(Q)))$$

$$s.t. \quad PX + P'X' = M$$

The authors do not explore consumer demand response to eco-labeling or impacts on demand for X or X' in either model.

Empirical Research

Several studies evaluate potential consumer demand and willingness to pay premiums for specific eco-labeled items. Empirical research on consumer response to eco-labels utilizes a variety of techniques. These include contingent valuation, conjoint analysis, hedonic price analysis, and demand system analysis.

The contingent valuation method (CVM), often used to value non-market environmental amenities, can be tailored to assess willingness to pay for a new product or

for a labeled product. In an open-ended format, CVM asks the survey respondent “what is the maximum amount that you would be willing to pay....” (Van Kooten and Bulte, p. 123). The dichotomous choice format presents respondents with a yes or no alternative, such as “would you be willing to pay \$A....” (Van Kooten and Bulte, p.124). Either format can be used to elicit consumer valuation of label attributes and their willingness to pay a price premium for a good with a certain label. In the spike model described by Kriström, consumers first are asked whether they would be willing to pay any amount for an environmental improvement (or any premium for a label attribute). Then the valuation function is elicited from those consumers willing to pay a positive amount.

Ozanne and Vlosky, Grönroos and Bowyer, and Jensen and Jakus conducted contingent valuation studies for environmentally certified wood products. Their results indicate that anywhere from 24% to 71% of consumers are willing to pay a non-zero price premium, depending on the study and specific product. Ozanne and Vlosky found that the average consumer would pay an 18.7% price premium for an environmentally certified 2”x4”x8’ wood stud with a base price of \$1, but only a 4.4% price premium for a new home (\$100,000 base price) built with environmentally certified wood. In their study, Grönroos and Bowyer concluded that consumers willing to pay extra for a home built with environmentally certified material would, on average, pay a 1 to 2% premium. Jensen and Jakus find a mean willingness to pay of 12.9% extra for a certified oak shelving board, 8.5% extra for a certified oak chair, and 2.8% extra for a certified oak table.

Contingent valuation is used to evaluate consumer preferences for eco-labeled fish in at least two studies. In a survey of U.S. consumers, Wessels, Johnston, and Donath

found that price, species, perception of fish stocks, and various consumer characteristics had statistically significant effects on respondents' choice of certified vs. uncertified seafood. Consumer willingness to pay a premium varied by species, with consumers more sensitive to increased premiums for cod than for salmon (Wessels, Johnston, and Donath). Johnston, et al. conducted a similar study of consumers in the U.S. and Norway. The authors found that price, species (cod or shrimp), certifying agency, membership in environmental organizations (U.S. only), fresh vs. frozen products (U.S. only), gender (Norway only), income (Norway only), and country of residence all had significant effects on the likelihood of purchasing certified vs. uncertified seafood. Norwegian respondents were more price sensitive.

Loureiro, McCluskey, and Mittelhammer used a contingent choice method to compare consumer preferences for organic, eco-labeled, and regular apples. The authors estimated probabilities of choosing one type of apple over the others depending on various consumer characteristics. They conclude that organic apples are perceived to have higher levels of positive attributes that affect consumer choice, with eco-labeled apples an intermediate choice. Eco-labeled apples were also the subject of a study by Blend and van Ravenswaay. The authors surveyed households with a contingent choice approach. The percentage of respondents choosing eco-labeled apples was 72.6% with no premium, 52.4% with a \$0.20 premium, and 42.3% with a \$0.40 premium over the base price of unlabeled apples (Blend and van Ravenswaay).

Hays used a contingent valuation approach with a discrete utility based framework to determine "willingness to pay for goods labeled with safe drinking water guarantees" (p.47). Among the 53% of consumers willing to pay extra for goods produced so as to

protect groundwater quality, 8.9% was the average maximum acceptable premium (Hays).

Conjoint analysis is another method that can be used to elicit consumer preferences and anticipate consumer responses to eco-labeled products. Conjoint analysis asks respondents to rate or rank products with different combinations or levels of attributes. The relative importance respondents place on price vs. levels of other attributes provides an estimate of the implicit prices of attributes (Roe, Boyle, and Teisl). In conjoint studies, different types of labels can be used to represent attributes and assess consumer valuation of those attributes.

Several studies use conjoint analysis to assess consumer valuation of product attributes similar to those represented by eco-labels. Sylvia and Larkin surveyed seafood wholesalers to assess the relative value they placed on various characteristics of Pacific whiting. The authors estimated the change in “conditional short-run, firm-level demands” (p. 503) for fillets with improved characteristics. Holland and Wessells asked consumers to rank salmon products according to the label, which presented information on type of production (farmed or wild-caught), safety inspection, and price. They found that consumers valued the safety inspection attribute most strongly, and that, on average, respondents favored farmed salmon over wild-caught. Baker and Burnham used conjoint analysis to assess consumer preferences and valuation of a genetically modified (GM) attribute in relation to other attributes of corn flakes. About 30% of respondents based their rankings on the GM content of the corn flakes (Baker and Burnham).

Whereas contingent valuation and conjoint analysis are used primarily for new products, for which insufficient market data is available, hedonic price analysis and

demand system analysis rely on historical market data to estimate the effects of various characteristics. Hedonic price estimates depend on both consumer valuations of attributes and producer costs of supplying the attributes, but “estimated hedonic price-characteristics functions typically identify neither demand nor supply” (Rosen, p.54).

Nimon and Beghin estimated hedonic prices for organic and “no-dye” attributes of cotton apparel items. The authors found an average price premium of 33.8% for the organic cotton attribute. A 14.8% discount was associated with the no-dye attribute, reflecting in part the lower costs of production (Nimon and Beghin).

Teisl, Roe, and Hicks used demand system analysis to assess whether dolphin-safe labels altered consumer behavior and increased the market share of canned tuna between April 1988 and December 1995. The authors estimated a system of share equations with an AIDS model and iterated seemingly unrelated regression using scanner data for canned tuna and substitute meat products (other canned seafood, canned red meat, and luncheon meats). They used monthly time series data and incorporated a media index. Although the market share for canned tuna declined during this time period, they found that the implementation of dolphin-safe labeling had a significantly positive effect, causing the market share to decline by less than if the labeling program had not been implemented. Their analysis considers the effect of the entire U.S. market converting to dolphin-safe labeling at the same time, so consumers did not have the choice between labeled and unlabeled tuna. The authors used compensating variation (CV) to measure a partial welfare effect of the dolphin-safe labeling. They estimated national annual CV to be between \$6 million and \$15 million.

Thompson and Glaser estimated own- and cross-price elasticities of demand for organic and conventional baby food using a quadratic almost ideal demand system (QUAIDS) model. The authors obtained monthly scanner data for the period between April 1988 and December 1999 from A.C. Nielsen and Information Resources, Inc. They note that organic baby food had a market share in 1999 of between 2.5% and 13%, depending on the specific type of product. In their analysis, organic and conventional baby food products were considered for five product categories. According to Thompson and Glaser's results, own-price demand for organic baby food is highly elastic, although these elasticities have declined over time as premiums have fallen and market shares have risen. Their analysis shows that own-price demand for conventional baby food is inelastic and that cross-price elasticity of demand for organic baby food is higher than that for conventional (i.e., changes in the price of conventional baby food have a stronger effect on demand for organic than changes in price for organic baby food have on conventional). As expected, most of these cross-price elasticities are positive, indicating that organic and conventional baby foods are substitutes.

Bjørner, Hansen, & Russell used a mixed logit model with panel data on Danish households to estimate the impact of the Nordic Swan environmental label on choice of toilet paper, paper towels, and detergents between 1997 and 2001. Controlling for brand influences, advertising, and other variables, they found that the Nordic Swan label increased consumer willingness to pay for toilet paper by 13 to 18 percent. The effect of the label on consumer choice of paper towels and detergent was less significant.

Various general conclusions can be drawn from these studies. A considerable segment of the population is willing to pay premiums for eco-labeled attributes, although

hypothetical estimates of this willingness may be inflated. Willingness to purchase an eco-labeled product increases as the number of (positive) attributes embodied in the label increases (e.g. organic vs. reduced pesticide or eco-labeled), but falls as the price premium rises. When expressed in absolute terms, the acceptable premium level rises as the price of the conventional product increases. However when expressed as a percentage of the conventional price, the acceptable premium for an eco-label is lower for more expensive products.

Consumer choice between an eco-labeled and unlabeled product is quite sensitive to variations in perceived product “quality.” It seems evident that most consumers are more willing to pay for private attributes, such as product quality and food safety, than for public attributes embodied in a product, such as diffuse environmental impacts. The food safety attribute (e.g. pesticide exposure) seems to be of greater importance in purchasing baby food than most other products, as evident by the significant market share for organic baby food.

Model of Consumer Response to Eco-Labels

We formulate a consumer model for the choice of an eco-labeled good, its unlabeled counterpart, and all other goods. Our model draws on elements of the product characteristics approach, imperfect information, and the impure public good model. In particular, it is similar to the model used by Cornes and Sandler for an impure public good. By adding the option to choose between an eco-labeled and unlabeled version of the same commodity, however, this model differs in an important sense. The model also has similarities to the consumer models presented by Stigler and Becker, and van Ravenswaay and Blend.

Although our model is intended for generic application to a variety of eco-labels, we use the example of an eco-label intended to distinguish leatherleaf ferns (an important crop in Florida's ornamental plant industry) that have been produced using environmental management practices (EMPs) that conserve water, reduce chemical use, and protect regional water quality in Florida. Stamps details irrigation and nutrient management practices for commercial leatherleaf fern production and asserts that such practices help protect ground water quality. An eco-label representing certified adherence to these EMPs would signal a public attribute (water quality protection) that affects residents and visitors to the producing region. For simplicity, assume that ferns may be produced either conventionally (without adherence to EMPs) or using "green" practices (EMPs that protect regional water resources). Ferns produced by EMP-certified nurseries may be sold with or without an eco-label. Ferns produced by uncertified nurseries must be sold without an eco-label.

The consumer is assumed to possess a utility function that depends on the levels of three characteristics: a private characteristic associated with fern consumption, a private characteristic associated with the numeraire commodity representing all other goods, and a public (bad) characteristic measured by a water quality index representing the level of contamination of water bodies in Florida. It is assumed that one unit of the numeraire good generates one unit of the numeraire characteristic. Also, the private characteristic from fern consumption is satisfied equally well by either unlabeled ferns or eco-labeled ferns, in a one-to-one relationship. Finally, we assume that one unit of conventional fern production (and consumption) reduces the water quality index by one unit, whereas "green" fern production has a negligible impact on water quality.

The consumer chooses quantities of the three market goods, so as to maximize utility subject to an income constraint and technical constraints that relate the market goods to characteristics valued by the consumer. The consumer's optimization problem is

$$(2-21) \quad \underset{y, q_u, q_e}{\text{Max}} U(Y, X, B)$$

$$\begin{aligned} & y + p_u q_u + p_e q_e = I \\ \text{s.t.} \quad & Y = y \\ & X = q_u + q_e \\ & B = B^0 + q_u + (1 - \rho) q_e \end{aligned}$$

where y , q_u , and q_e are quantities of the numeraire good, unlabeled ferns, and ferns labeled with an environmental claim respectively. The variables Y , X , and B are quantities of the private numeraire characteristic, the private characteristic associated with ferns, and the public bad respectively. A higher level of B represents greater water contamination (measured by a water quality index). B^0 is the level of water contamination generated by others (through the production and consumption of ferns not adhering to EMPs) and is considered exogenous to the individual consumer's decision. The exogenous parameters I , p_u , and p_e represent the consumer's disposable income, the price of unlabeled ferns and the price of environmentally-labeled ferns respectively. Finally, the parameter, ρ , represents the consumer's trust in the environmental claim. Thus, the coefficient $(1 - \rho)$ has a subjective element based on consumer perceptions, similar to $g(\cdot)$ in the Stigler and Becker model.

Whereas a small segment of consumers may have been taking the producer's word or relying on a first-party (producer) environmental claim prior to eco-labeling, a third-party verified seal-of-approval represents an improvement in information. In particular,

the credibility of the environmental claim increases. Consumers would attribute a higher probability that an environmental claim is true. Thus, the introduction of an eco-label is represented by an increase in the value of ρ on a 0-1 scale. If $\rho = 0$, an environmental claim has no credibility. If $\rho = 1$, an environmental claim has perfect credibility. The eco-label design, trustworthiness of the certifying organization, and strength of monitoring and verification activities may affect the credibility of an eco-label.

Assuming a positive quantity of Y (all other goods) is always purchased, necessary first-order conditions for utility maximization are

$$(2-22) \quad \frac{U_X}{U_Y} + \frac{U_B}{U_Y} \leq p_u$$

and

$$(2-23) \quad \frac{U_X}{U_Y} + (1 - \rho) \frac{U_B}{U_Y} \leq p_e.$$

where U_j is marginal utility with respect to characteristic j . Since Y and X are positive characteristics, $U_Y > 0$ and $U_X > 0$. Because B is a negative characteristic, $U_B < 0$.

Equation 2-22 holds with equality if $q_u > 0$, and Eq. 2-23 holds with equality if $q_e > 0$.

The two first-order conditions expressed in Eqs. 2-22 and 2-23 are similar to Eqs. 2-2, 2-8, and 2-11 from Gorman, Michael and Becker, and Ladd and Suvannunt. If positive quantities of a market good are purchased, the market price equals the sum across all jointly produced characteristics of the marginal implicit characteristic values times the coefficients measuring the amount of a characteristic embodied in the market good.

Equation 2-22 implies that the marginal rate of substitution between X and income (MRS_{XY}) plus the marginal rate of substitution between B and income (MRS_{BY}), which is negative, equals the market price for consumers that purchase unlabeled ferns. If eco-

labeled ferns are purchased, Equation 2-23 implies that $MRS_{XY} + (1-\rho)MRS_{BY}$ equals market price, where $(1-\rho)$ is the expected contribution of q_e to the public bad, B .

For consumers who purchase both unlabeled and eco-labeled ferns, or who are indifferent between the two, Eqs. 2-22 and 2-23 together imply

$$(2-24) \quad -\rho \frac{U_B}{U_Y} = p_r$$

where p_r is the price premium (i.e., $p_e - p_u$). Equation 2-24 suggests that the price premium equals the marginal consumer's valuation of water quality ($-U_B/U_Y$) times the perceived difference in impact on water quality between one unit of the unlabeled and one unit of the eco-labeled ferns (ρ). If $\rho = 1$, the price premium is the marginal consumer's valuation of avoiding the water contamination resulting from conventional production of one unit of ferns. This interpretation applies to the consumer who chooses to purchase a positive quantity of ferns so that $U_X/U_Y = p_e$ and is marginal in the sense that $-\rho U_B/U_Y = p_r$. Other (intramarginal) consumers may maximize utility by purchasing a positive quantity of eco-labeled ferns so that $U_X/U_Y = p_e$, but have a water quality valuation that exceeds the price premium (i.e., $-\rho U_B/U_Y > p_r$).

Corner solutions imply that the conditions represented by Eqs. 2-22, 2-23, and 2-24 do not all hold with equality. Considering the possibility of corner solutions, four types of consumers are distinguished with respect to our consumer model. The first type of consumer (Type 1) does not buy any ferns. The second type of consumer (Type 2) purchases unlabeled ferns, but no eco-labeled ferns. The third type of consumer (Type 3) purchases eco-labeled ferns, but no unlabeled ferns. The last type of consumer (Type 4) buys both unlabeled and eco-labeled ferns. The necessary relationship between marginal characteristic values and market price for each consumer type is shown in Table 2-1.

Table 2-1. First-order conditions for four different consumer types

Type 1 $q_u = 0, q_e = 0$	Type 2 $q_u > 0, q_e = 0$	Type 3 $q_u = 0, q_e > 0$	Type 4 $q_u > 0, q_e > 0$
$\frac{U_X + U_B}{U_Y} < p_u$	$\frac{U_X + U_B}{U_Y} = p_u$	$\frac{U_X + U_B}{U_Y} < p_u$	$\frac{U_X + U_B}{U_Y} = p_u$
$\frac{U_X + (1 - \rho)U_B}{U_Y} < p_e$	$\frac{U_X + (1 - \rho)U_B}{U_Y} < p_e$	$\frac{U_X + (1 - \rho)U_B}{U_Y} = p_e$	$\frac{U_X + (1 - \rho)U_B}{U_Y} = p_e$
$-\rho \frac{U_B}{U_Y} \geq p_r$	$-\rho \frac{U_B}{U_Y} < p_r$	$-\rho \frac{U_B}{U_Y} > p_r$	$-\rho \frac{U_B}{U_Y} = p_r$

Demand for each type of fern is a function of the prices of both types of ferns, a price index representing the numeraire, consumer disposable income, the parameter ρ , and consumer preferences (which typically are assumed to be stable). Demand for the unlabeled ferns can be specified as $D_u(p_u, p_e, p_y, I, \rho)$. Demand for the ferns labeled with an environmental claim can be formulated as $D_e(p_u, p_e, p_y, I, \rho)$. Additional parameters could be added representing characteristics of the consumer population, such as environmental awareness or other factors affecting the perceived relationship between fern production, q , and water quality, B .

Joint production, the presence of multiple goods producing a single characteristic, and the existence of corner solutions cause difficulties for assessing the comparative static properties of demand from this model. Without restrictive assumptions, comparative static results for the effect of a change in the parameter ρ are ambiguous for X , Y , q_u , and q_e . If improved water quality is not an inferior good, and given well-behaved utility functions, the effect on B^i of increasing ρ is negative, where B^i is the individual consumer's contribution to the public bad, B .

A graph of the constraint set in characteristics-space, shown in Figure 2-1, provides insight regarding the effects of eco-labeling, represented by an increase in the parameter ρ . Taking B^0 as given and setting it at the origin, the difference, $B - B^0 = B^i$, is the

individual's contribution to the public bad. The constraint set in characteristics space is defined by the equations:

$$(2-25) \quad Y + \left(\frac{p_r}{\rho} + p_u \right) X - \left(\frac{p_r}{\rho} \right) B^i = I$$

and

$$(2-26) \quad B^i = \alpha X + (1 - \alpha)X(1 - \rho),$$

where Eq. 2-26 restricts the relationship between B^i and X to be defined by a convex combination of q_u and q_e .

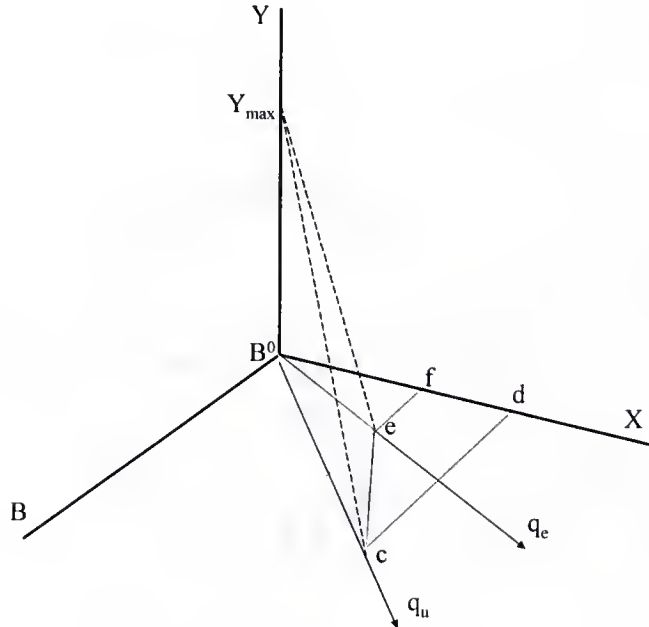


Figure 2-1. Constraint set in 3-dimensional Y-X-B space

In Figure 2-1, the consumer's constraint set is bounded by the pyramid ceB^0Y_{max} . The relevant surface for utility maximization is the surface ceY_{max} . An increase in the parameter, ρ , rotates the q_e vector toward the X -axis, generating less B^i per unit of X . The

corner point e moves toward the point f , and the base of the pyramid bounded by ce shifts out toward cf . A change in ρ is equivalent to a price change in characteristics space.

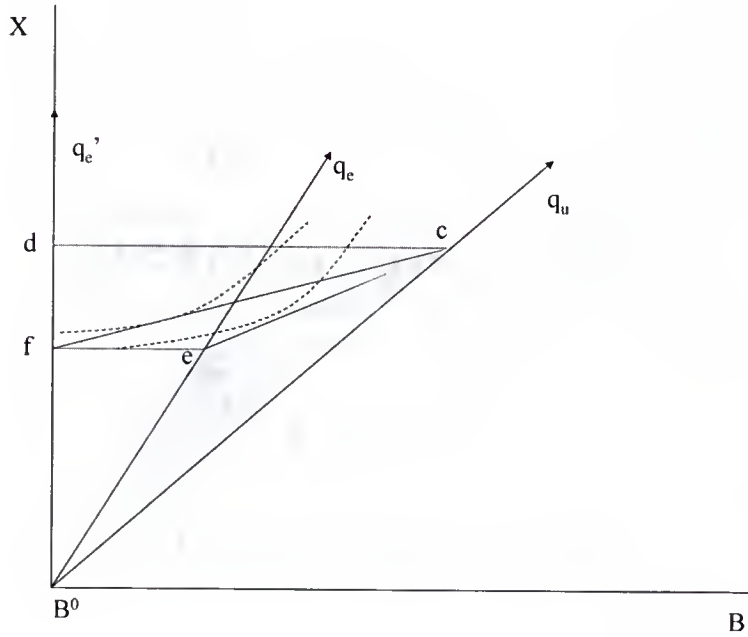


Figure 2-2. Constraint set in 2-dimensional X-B space

Figure 2-2 shows the constraint and indifference curves in two dimensional X-B space. Because B is a negative characteristic, the indifference curves, represented by the dashed lines, are positively sloped. The slope of the constraint line ce is

$$(2-27) \quad \frac{p_r/\rho}{(p_r/\rho) + p_u}.$$

As ρ approaches 1, the vector q_e rotates toward q_e' , and the slope of ce falls (as it rotates toward cf). A substitution effect implies lower levels of B^i (which is desirable) and lower levels of X . An income effect allows the consumer to obtain higher levels of X for a given level of B^i . Assuming that B is a normal “bad” (i.e., water quality is not an inferior good) the income effect further reduces the optimal level of B for the individual consumer. For fixed market prices, p_u and p_e , an increase in the parameter ρ , representing

the credibility an eco-label lends to an environmental claim, has a non-positive effect on B^i . The effect on ordinary (uncompensated) demand for X and Y is ambiguous.

Intuitively, one would expect an eco-label to increase demand for the good making the environmental claim and decrease demand for the unlabeled good. Indeed, for consumer Types 1 and 2 (representing corner solutions, in which $q_e = 0$ prior to labeling) the effect of eco-labeling on demand for the unlabeled good is nonpositive, and the effect on demand for the “green” good is nonnegative. For example, consumer Type 1 faces first-order conditions described in Table 2-1. An increase in the value of ρ raises the perceived value of the eco-product relative to its price, and increases the likelihood that consumer Type 1 will purchase the environmentally differentiated ferns. For consumer Type 2, an increase in the value of ρ increases the likelihood that he will switch from consumption of unlabeled ferns to eco-labeled ferns.

For consumer Types 3 and 4, however, the effect of eco-labeling (increasing ρ), on the quantities q_e and q_u consumed, is theoretically ambiguous without additional assumptions. The possible (although unlikely) result the q_u could rise, depends on the idea that the eco-label leads the (pre-labeling) consumer of q_e to believe that his contribution to the public bad, B , is lower than previously thought. After labeling, the consumer could choose more q_u and less q_e to obtain more X , but with a lower perceived contribution to the negative characteristic B . As long as the perceived reduction in B owing to the increase in ρ outweighs the increase in B owing to the higher quantity of q_u , the consumer perceives a net reduction in B and an increase in X .

This theoretical possibility is ruled out, however, if we assume that eco-labeling does not change the consumer’s marginal valuation of the public bad, B . Specifically,

under the assumptions of separable utility and negative, constant marginal utility with respect to B (within the relevant range), an increase in the value of ρ has an unambiguously positive effect on eco-demand and an unambiguously negative effect on unlabeled demand by all consumer types. Under this assumption (and the condition that both q_e and q_u are positive prior to labeling) the comparative static effects on q_e and q_u are

$$(2-28) \quad \frac{\partial q_e}{\partial \rho} = \frac{-p_u^2 U_B U_{YY} - U_B U_{XX}}{U_{XX} U_{YY} (-p_u^2 - p_e^2 + 2p_u p_e)}$$

and

$$(2-29) \quad \frac{\partial q_u}{\partial \rho} = \frac{p_u p_e U_B U_{YY} + U_B U_{XX}}{U_{XX} U_{YY} (-p_u^2 - p_e^2 + 2p_u p_e)}$$

where U_{jj} is the second partial derivative of utility with respect to characteristic j . Under standard assumptions, U_{YY} , U_{XX} , and U_B are negative. Additionally, as long as p_u does not equal p_e , Eq. 2-28 is clearly positive, and Eq. 2-29 is clearly negative. Under the assumption of separable utility and negative, constant marginal utility with respect to B , eco-labeling causes an increase in consumption of environmentally differentiated ferns and a decrease in consumption of unlabeled ferns.

Much like advertising, eco-labels increase the perceived quality of the environmentally differentiated product, increasing its demand relative to similar competing products. In aggregate, eco-labels supported by a credible third-party certification process can be expected to increase demand for the good making the environmental claim and decrease demand for the unlabeled version of the same commodity, *ceteris paribus*.

CHAPTER 3 PRODUCER SUPPLY RESPONSES TO ECO-LABELS

Whereas an understanding of consumer response to eco-labels provides insight regarding potential effects on demand, the effects on production and ultimately the environment depend on producer responses. In this chapter, we review literature and introduce a producer model that provides a framework for anticipating supply responses to eco-labels.

Literature Review

Theories of producer choice of product quality, advertising level, and technology adoption provide a framework for analyzing producer response to certification and labeling programs. We review literature on producer behavior regarding product quality, where quality refers to a product characteristic that can be changed through adjustments to the production process. Also, models of producer decisions concerning advertising, technology adoption, and environmental certification are reviewed. In addition, we summarize existing literature on empirical research pertaining to environmental management, certification and labeling decisions of producers.

Theoretical Models of Producer Decisions

Dorfman and Steiner (p. 832) derive the marginal conditions for a firm to choose the optimal level of product quality, defined on a single dimension. Given an average cost function, $c = c(q, z)$, and demand curve, $q = f(p, z)$, where q is quantity, z is quality, c is average production cost, and p is product price, the first-order (necessary) condition for profit maximization with respect to the quality choice in their model is

$$(3-1) \quad -\frac{\partial f}{\partial p} = \frac{\partial f / \partial z}{\partial c / \partial z}.$$

The first-order condition expressed in Eq. 3-1 can be written as

$$(3-2) \quad \frac{\partial p}{\partial z} = \frac{\partial c}{\partial z}.$$

Equation 3-2 equates the marginal change in price with the marginal change in average cost, both with respect to product quality. In other words, firms will increase quality as long as the resulting increase in unit price is greater than the increase in average production cost, for any fixed quantity of output.

Rosen considers the case of individual production establishments (plants), each producing only one type of product. An individual plant has a total cost function, $C(q, z; \beta)$, where q is production quantity, z is the vector of product characteristics, and β represents cost function parameters that vary among plants. Each plant chooses q and z to maximize profit, $\Pi = qp(z) - C(q, z_1, \dots, z_n)$, where $p(z)$ is the product price as a function of characteristics. The first-order (necessary) conditions for profit maximization in Rosen's model are

$$(3-3) \quad p(z) = C_q(q, z_1, \dots, z_n)$$

and

$$(3-4) \quad p_i(z) = C_{zi}(q, z_1, \dots, z_n)/q.$$

Equation 3-3 is the condition that marginal cost (relative to quantity) equals unit price. Equation 3-4 is the condition that "marginal revenue from additional attributes equals their marginal cost of production per unit sold" (Rosen, p.42). This latter condition is essentially the same as the optimal quality condition identified by Dorfman and Steiner. A firm will improve the quality of its product as long as the resulting

increase in price is greater than the increase in average cost, for a given quantity of output.

Stigler and Becker describe a firm's profit function with respect to quantity of output and level of advertising as

$$(3-5) \quad \Pi = p_q q - C(q) - A p_a .$$

Noting Eq. 2-14 and the relationship between implicit demand for a characteristic and market demand for a good, Stigler and Becker substitute the shadow value, π_z , of the product's characteristic times the coefficient, $g(A)$, measuring the amount of quality characteristic contained in the market good, for the market price. Then the profit function can be written as

$$(3-6) \quad \Pi = \pi_z g(A) q - C(q) - A p_a .$$

The necessary first-order condition for profit maximization with respect to advertising in Stigler and Becker's model is

$$(3-7) \quad \frac{\partial p_q}{\partial A} = \pi_z \frac{\partial g}{\partial A} q = p_a .$$

Dividing through by q , this condition is similar to Eqs. 3-2 and 3-4. The only technical difference is that the effect of advertising increases market demand (price), not by shifting implicit demand for characteristics, but by increasing the input-output coefficient describing the (perceived) quality of a market good.

Tirole analyzes the case of a monopolist choosing optimal quantity and quality of output. Given an inverse demand function, $P(q, z)$, and a total cost function, $C(q, z)$, where q is quantity and z is quality, the monopolist would maximize

$$(3-8) \quad \Pi = qP(q, z) - C(q, z) .$$

The necessary first-order condition with respect to the choice of quality for Tirole's monopolist model is

$$(3-9) \quad qP_z(q, z) = C_z(q, z),$$

where P_z and C_z are partial derivatives with respect to quality.

Ideally a social planner would try to maximize social welfare, defined as “the difference between gross consumer surplus and production cost” (Tirole, p.100). The social planners objective function would be

$$(3-10) \quad W(q, z) = \int_0^1 P(x, z)dx - C(q, z).$$

Tirole's formulation in Eq. 3-10 assumes unit demands among the consumer population. “[$P(x, z)$] is then the price that makes the x th consumer indifferent between buying one unit of the good of quality [z] and not buying” (Tirole, p.100). The necessary first-order condition for the social planner in Tirole's model is

$$(3-11) \quad \int_0^1 P_z(x, z)dx = C_z(q, z).$$

Tirole explains the difference between the first-order conditions for the monopolist vs. the social planner. “The incentive to provide quality is related to the marginal willingness to pay for quality, for the marginal consumer in the case of a monopolist and for the average consumer in the case of a social planner” (Tirole, p.101).

We note that dividing both sides of Eq. 3-9 by q produces the now familiar condition expressed in Eq. 3-2 from Dorfman and Steiner. The first-order condition for optimal choice of quality is no different for the monopolist than for the competitive firm. A competitive firm cannot influence price by changing quantity, as a monopolist can, but it can influence price by changing quality. For any given level of quality, the competitive

firm still acts as a price-taker. Implications are that neither the monopolist, nor the competitive firm, will provide the socially optimal level of product quality, except under very restrictive conditions.

Hays models a firm facing a discrete choice of quality levels (e.g., whether to obtain environmental certification—and label its products as such—or not). The firm's profit function in Hays' model is defined over discrete alternatives as $\Pi^* = \max\{\Pi^E, \Pi^N\}$.

If the firm chooses to adopt environmental certification and labeling its profit is

$$(3-12) \quad \Pi^E = p_e q - C(q) - F_e.$$

If the firm chooses not to adopt environmental certification and labeling its profit is

$$(3-13) \quad \Pi^N = p_n q - C(q) - F_n.$$

The term $C(q)$ is the total variable cost function, and F_i is total fixed cost. Hays' formulation allows one to estimate empirically the firm's adoption decision as the probability that $\Pi^E > \Pi^N$, which depends on the firm's price and cost expectations, as well as firm characteristics.

Although expected short-run profit is often a primary objective of producers, other objectives enter their decision-making as well. Risk is often an important factor in the decisions of a producer or investor. One formulation has the producer maximizing a utility function defined over expected return and a measure of risk. Risk could be measured as variance of returns (Markowitz) or mean absolute deviation (Hazell). Isik and Khanna model a farmer's decision to adopt site-specific technologies (SSTs) and consider a farmer's preferences defined over the mean and standard deviation of a stochastic profit function. In their model, the farmer's objective function is:

$$(3-14) \quad \underset{x, I}{Max} U\left(\Pi^c + I(\Pi^s - \Pi^c - K), \sigma^c + I(\sigma^s - \sigma^c)\right),$$

where the decision variables X and I refer to variable input level and the choice of adopting SSTs respectively ($I = 1$ if SSTs are adopted; $I = 0$ if SSTs are not adopted). The term Π is quasi-rent, σ is standard deviation of quasi-rent, and K is the fixed cost of implementing SSTs. The superscripts c and s refer to conventional practices and site-specific technologies respectively.

Farmers and firms consider various other factors in their decisions. Philosophical outlook, environmental and health concerns, risk of liability for environmental damage, and pressure from various groups can influence the response to voluntary environmental programs. Empirical studies demonstrate the importance of these factors.

Empirical Research

Henriques and Sadorsky find that firms do in fact respond to pressure from customers, shareholders, government, and neighborhood and community groups in formulating environmental plans. Evidence also suggests that public recognition and the risk of environmental liability provide incentives for firms to adopt voluntary environmental management systems, trading off short-run returns for expected long run profitability (Khanna and Damon; Khanna and Anton). The results of a survey of organic citrus growers, presented in Chapter 6, demonstrate that environmental and health concerns, as well as the threat of environmental liability, were significant factors in the decision by some growers to adopt organic practices.

Gobbi collected data on five different types of coffee farms in El Salvador to assess the financial feasibility of obtaining “biodiversity-friendly” certification. Simulation results from the study found that mean expected gains in net present value associated with certification were positive for all five farm types. Despite the favorable results,

Gobbi concludes that the initial capital required to convert to biodiversity-friendly practices and to obtain certification acts as a deterrent, especially for small growers.

Murray and Abt estimated a compensation function for eco-certified forestry in the southeastern United States. The function traces out the threshold price premiums necessary for heterogeneous forest enterprises to convert land to eco-certified practices. Their simulation results show that a significant portion of forest land would adopt certification at relatively modest price premiums. The authors caution that environmental improvement would be modest at low price premiums, because the only adopters would be forest enterprises that are already using environmentally friendly practices.

Boltz, et al. compared the financial performance of conventional and reduced-impact logging (RIL) in the Brazilian Amazon. The authors found that reduced-impact logging is more profitable than conventional and can reduce production costs in some cases. They suggest that uncertainty about new practices is one reason that RIL is not more widely adopted.

Bell, et al. identified factors influencing the probability that a landowner would participate in Tennessee's Forest Stewardship Program. The authors found that a landowner's attitude towards conservation goals and knowledge of forestry programs can have a stronger effect on the likelihood of participation than monetary incentives. They conclude that environmental education, training and technical assistance would be more effective than financial cost-share incentives at increasing participation in the environmental management program.

Hays surveyed firms in Oregon to assess their likelihood of participating in an environmental labeling program to protect water quality. She found that participation

costs and consumer demand expectations were primary motivators. Other factors had little significance.

Model of Producer Response to Eco-Labels

A producer model provides insight as to the most likely effects of eco-labeling on supply. Producers want to maximize profits from their production enterprise, although other objectives may enter their decision-making process. Eco-labeling enables producers who generate environmental benefits to differentiate their products in the market with the potential for higher prices and higher returns. In addition to the incentives created by price premiums for eco-labeled products, producers may be motivated to adopt environmental certification because of a various other reasons described previously.

Producer response to environmental labeling and certification can be broken down into three separate decisions. First, a producer can choose to adopt EMPs or not on a particular production block. If a producer adopts EMPs, he then has the option to obtain certification or not. Producers that are EMP-certified have the option to market their products with an eco-label or sell them undifferentiated through conventional market channels. A producer with multiple production blocks or plots can make a separate choice for each production block.

Considering the three related decisions facing a producer for a given production block, a possible formulation of the producer problem is

$$\begin{aligned}
 (3-15) \quad & \underset{q, q_g, q_l, q_e}{\text{Max}} \Pi = p_c q - C(q, w, k) - c_g(w, k, v)q_g - c_l(k, v, \rho)q_l - c_e(\rho)q_e + p_r(\rho)q_e \\
 & \text{s.t.} \quad q_g \leq q \\
 & \quad q_l \leq q_g \\
 & \quad q_e \leq q_l
 \end{aligned}$$

where Π is the producer's expected profit. Decision variables are q , q_g , q_t , and q_e , which are the quantity of total output, quantity of "green" output, quantity of certified output, and quantity marketed with an eco-label respectively. The parameters, p_u and p_r , are the conventional (unlabeled) price and the eco-label price premium ($p_r = p_e - p_u$) respectively. The term $C(.)$ is a standard cost function, and the $c(.)$ terms are additional per unit costs (additional to C/q). In particular, $c_g(.)$ is the additional (average) production cost associated with using "green" practices, $c_t(.)$ is the additional (average) cost of obtaining certification, and $c_e(.)$ is the additional (average) cost of marketing with an eco-label. The parameter w represents a vector of input prices, k is a vector of characteristics associated with an individual producer and production block, v is a vector of nonprice incentives created by certification and labeling programs, and ρ is the credibility or level of consumer trust in an environmental claim.

Additional clarification is in order, in particular for the non-price incentives, v . Here we consider two types of nonprice incentives identified in the literature. The first one is a reduction in costs of complying with EMP ("green") production standards. In some cases, the development of an environmental certification program improves the information available to producers. Research and extension activities that disseminate information in conjunction with a certification program can reduce the costs of green production. For example, some reduced-impact logging techniques have been shown to increase efficiency and lower costs (Boltz et al.). Also, best management practice (BMP) and integrated pest management (IPM) programs have been known to reduce producer costs, in particular expenditures on pesticides, water, and fertilizers (Leppla; Stamps). "IPM certification programs have been promoting environmental stewardship, reducing

production and processing costs, improving profits through IPM labeling, and protecting growers and processors from accusations of pesticide misuse” (Leppla, p. 2).

Development of BMP and IPM programs and related education and extension activities can help producers become more efficient, increasing grower knowledge of techniques to reduce costs and environmental impacts, while maintaining yields. Thus the parameter v , appearing in the $c_g(.)$ function, represents information that reduces costs of using “green” practices. For some producers, “green” production may be less costly than conventional production. The $c_g(.)$ function would take a negative value for those producers.

The second type of non-price incentive represented by v relates to a reduction in the perceived risk of a producer being held liable for environmental damages. This incentive has been documented or discussed by Henriques and Sadorsky; Khanna and Damon; Khanna and Anton; Leppla; and WWF. Although not an immediate (short-run) cost of production, the perceived threat of liability is part of a producer’s long-run cost expectations and could be incorporated in the cost function, $C(.)$. If an EMP certification has legal standing with the government, then obtaining certification could reduce the perceived risk of liability for a producer. Thus, the parameter, v , in the $c_l(.)$ function would have a cost-reducing effect. The full cost of certification for a producer includes a certification fee paid to the certifying agency and a reduction in expected costs associated with environmental liability. The net “cost” of certification for a given producer may be positive or negative.

Another point of clarification regards the inclusion of the parameter ρ in the certification and eco-labeling cost functions, $c_l(.)$ and $c_e(.)$. Steps that increase the level of credibility of an environmental claim in the eyes of the consumer include on-site

inspection, monitoring and oversight activities by the certifying body, as well as chain-of-custody and identify preservation measures to keep the certified product separate from uncertified products through processing, storage, transport, and distribution. In this sense, additional certification expenses (and therefore fees passed back to the producer) and marketing costs associated with selling an eco-labeled product must be incurred in order to increase eco-label credibility, ρ . Thus, higher certification and labeling costs are associated with higher levels of credibility. If a producer has a choice between multiple certifying bodies and eco-labels representing a similar environmental standard, ρ would be a decision variable affecting costs and the price premium received for a particular eco-label. More typically, however, a producer has only the choice of one eco-label for a particular environmental standard, and must either accept or reject its associated costs and price premium. In that case, ρ is an exogenous variable associated with the available certification and labeling program.

The formulation of the producer problem in Eq. 3-15 requires that the quantity of output using green practices, q_g , is less than or equal to the producer's total output q . Likewise, certified output, q_t , must be less than or equal to q_g , and eco-labeled output, q_e , must be less than or equal to certified output.

The Lagrangian for the producer problem generates the following Kuhn-Tucker conditions:

$$(3-16) \quad p_u - C_q(q) + \mu_1 \leq 0$$

$$(3-17) \quad -c_g(v) - \mu_1 + \mu_2 \leq 0$$

$$(3-18) \quad -c_t(v, \rho) - \mu_2 + \mu_3 \leq 0$$

$$(3-19) \quad p_r(\rho) - c_e(\rho) - \mu_3 \leq 0$$

$$(3-20) \quad \frac{\partial p_r}{\partial \rho} q_e - \frac{\partial c_e}{\partial \rho} q_e - \frac{\partial c_t}{\partial \rho} q_t \leq 0$$

where μ_i is the Lagrange multiplier associated with each of the three constraints in Eq. 3-15, numbered consecutively. C_q is marginal production cost, and c_g , c_t , and c_e represent additional per unit costs described previously. It is assumed that the producer is a price-taker with respect to p_u and p_r , and that the additional average costs, c_g , c_t , and c_e do not change with output quantity q .

Given these assumptions, the profit-maximizing producer will choose an output level that equates marginal cost with the unlabeled output price plus additional net per-unit benefits that accrue only if the producer chooses to comply with EMPs (assuming total price is higher than total average cost). If the producer chooses not to comply with EMPs ($q_g = 0$), then $\mu_1 = 0$, and $p_u = C_q(q)$. If the producer chooses to comply with EMPs ($q_g > 0$), then $\mu_1 > 0$ and $p_u + \mu_2 - c_g(v) = C_q(q)$, where μ_2 represents any additional net per unit benefits associated with certification and labeling. If the producer complies with EMPs, but does not choose to obtain certification and market products with an eco-label ($q_t, q_e = 0$), then $\mu_2 = 0$, and $p_u - c_g(v) = C_q(q)$. We note that in this case, the additional “cost” associated with green production for the producer must be negative, (i.e., this producer associates net benefits with green production over conventional production). If a producer chooses green production, certification, and labeling, then

$$(3-21) \quad p_u + p_r(\rho) - c_g(v) - c_t(v, \rho) - c_e(\rho) = C_q(q).$$

The eco-label price ($p_e = p_u + p_r$) minus any additional per unit costs associated with green production, certification, and labeling equals the marginal production cost for the profit-maximizing producer.

By assuming that the producer is a price taker and that additional per unit costs do not vary with output quantity, the three constraints in Eq. 3-15 must either hold with equality or the left-hand-side variable equals zero. This implies that producers face a discrete choice relative to the three decisions concerning green production, certification, and labeling. Either all the output from a production block is “green” or none of it is. Likewise, if the block is managed using “green” practices, either the entire block is certified or not. Similarly, either the entire output from one production block is labeled, or none of it is.

To show that our model relates closely to the producer models in the literature, we simplify the model formulated in Eq. 3-15 by assuming that the producer faces only one decision, either “green” production, certification, and labeling, or conventional production. For the marginal producer, indifferent between the two options, the following conditions must hold

$$(3-22) \quad p_u = C_q(q)$$

$$(3-23) \quad p_r(\rho) = c_g(v) + c_l(v, \rho) + c_e(\rho)$$

Equation 3-23 is a discrete choice condition similar to Eqs. 3-2, 3-4, 3-7, and 3-9 identified by Dorfman and Steiner, Rosen, Stigler and Becker, and Tirole. The left-hand side of Eq. 3-23 is the change in output price received by adopting green practices, certification, and labeling. The right-hand side of Eq. 3-23 is the change in average cost associated with adopting green practices, certification, and labeling. Our discrete choice formulation assumes that the producer does not have control over the credibility parameter ρ .

In the case that the producer can choose among multiple certifying agencies and multiple labels for the same environmental management standard, and that each label has a different level of credibility in the eyes of consumers, the profit-maximizing producer would choose a label and the associated value of ρ so that Eq. 3-20 holds with equality. Dividing Eq. 3-20 through by $q_e = q_b$, our result is essentially the same as the Dorfman and Steiner and Rosen results expressed in Eqs. 3-2 and 3-4. When the producer can vary quality of output, she will increase quality until the marginal change in price with respect to quality just equals the marginal change in per unit cost with respect to quality. Likewise, the producer in our model would choose ρ so that the marginal increase in the price premium with respect to ρ just equals the marginal per unit costs associated with increasing ρ .

Assuming that other exogenous factors, such as w and k , are constant, producer responses to the development of environmental certification and labeling programs depend on the effects of v and ρ . Based on aggregate producer responses, we can specify supply functions, $S_u[p_u, p_r(\rho, p_u), v, \rho]$ and $S_e[p_u, p_r(\rho, p_u), v, \rho]$, where $p_r = p_e(\rho) - p_u$. Nonprice incentives created by dissemination of information to producers, and by the opportunity to lower the risk of liability for environmental damages, reduce “green” production costs relative to conventional production. The enhancement of credibility of environmental claims generated by an eco-label increases the price premium received by producers of eco-labeled products. Both these price and nonprice incentives serve to increase “green” supply relative to conventional supply.

CHAPTER 4

ANTICIPATING THE EFFECTS OF ECO-LABELING ON THE ENVIRONMENT

Given our conclusions about the direct effects of eco-labeling on demand and supply for competing products, we now extend the analysis to consider the ultimate effect of eco-labeling on the environment. After a brief literature review, two theoretical models are used to identify the connection between the direct effects of eco-labeling on demand and supply and the ultimate environmental impact. First, a two-product, partial-equilibrium model is used to identify the effects of eco-labeling on conventional production quantity under different market conditions. Second, a price-endogenous programming model is created to simulate the introduction of an eco-label and the resulting effects on production, land use, and the environment in a producing region. Equilibrium conditions are identified and the simulation model is run using the General Algebraic Modeling System (GAMS) to demonstrate hypothetical effects under different conditions. Lastly, results are summarized and discussed.

Literature Review

The debate over the environmental effectiveness of eco-labeling is highlighted in three recent articles on shade-grown coffee labeling in the journal *Conservation Biology*. Rappole, King, and Vega Rivera (2003a; 2003b) argue that shade-grown coffee programs have had negative impacts on land-use and biodiversity in Latin America. “If the sole result of the promotion of shade coffee were to encourage growers to convert sites that are currently in sun coffee to shade coffee, then there could be few qualms from a conservation perspective about the campaign so wholeheartedly endorsed not only in lay

publications but scientific journals as well” (Rappole, King, and Vega Rivera 2003a, p.334). The authors suggest, however, that a common standard protecting biodiversity is lacking and that “promotion far outstrips certification” (Rappole, King, and Vega Rivera 2003b, p.1848). They contend that promotion of shade-grown coffee has caused additional clearing of native forests to the detriment of biodiversity in the tropics.

Philpott and Dietsch defend coffee certification and labeling programs for their conservation successes and for reducing incentives to employ more harmful land-use practices. These authors contend that coffee overproduction and low prices led to “widespread environmental and social disasters” (p.1845) and created incentives for forest conversion to sun coffee, cattle pasture, swidden agriculture, and coca and poppy production. They point out that leading certification programs require “a diverse canopy and certain levels of structural diversity” (Philpott and Dietsch, p.1845) and can provide an economically viable alternative to activities with far worse environmental impacts.

The key source of disagreement between the two sets of authors, cited above, concerns alternative land-uses. Is pristine forest, or more intensive agriculture, the primary land-use alternative to shade-grown coffee? Does promotion of eco-labeled coffee lead to the clearing of more primary forest land or deter the conversion of land to sun coffee, cattle pasture, and other environmentally inferior land-uses?

In other literature, one finds a variety of opinions about the potential effectiveness of eco-labels. Antle provides an optimistic assessment of the potential for labeling and other information-based policies to affect positive environmental change. Murray and Abt, and Kiker and Putz, cast doubt upon the ability of environmental certification and labeling programs to protect the environment. Despite speculation of all sorts, the U.S.

Environmental Protection Agency (1998, p. 59) concluded in 1998 that “to date, the effectiveness of labels as a policy tool has not been thoroughly studied.”

As described in previous chapters, several studies have considered individual components of an eco-label's effectiveness. Some studies have evaluated consumer demand and willingness-to-pay premiums for eco-labeled products. Others have analyzed producer responsiveness to certification and labeling programs. Although these studies provide empirical evidence regarding important components of an eco-label's impact on demand or supply under specific circumstances, they do not consider the full interaction between supply and demand for competing products and the ultimate environmental outcome.

The Environmental Protection Agency (1994, p. 5) describes the theoretical link between the effect of eco-labels on consumer demand and environmental outcomes:

With increased acceptance of an environmental label, consumer behavior changes may take the form of increased demand for products with [eco-labels], or decreased demand for products carrying negative warning labels. This in turn would effect a market shift toward products that are presumably less damaging to the environment than other similar products in their classes. In theory, a market shift of this sort will reduce the total environmental impacts of consumer products.

The exact linkages between consumer awareness, demand, and environmental impacts are left rather ambiguous. Several questions remain. Under what circumstances would an eco-labeling program be most effective at reducing adverse environmental impacts? Under what circumstances would eco-labeling be least effective? Is it possible that an eco-labeling program could increase environmentally harmful production in some cases? These questions are addressed in this chapter.

Few studies analyze the effects of eco-labeling by considering supply and demand factors for both the eco-labeled and unlabeled product, and the ultimate impact on the

environment. Mattoo and Singh used a graphical analysis to model supply and demand for an environmentally friendly product and its environmentally unfriendly counterpart. They produced an interesting result: if the quantity of eco-supply exceeds the quantity of eco-demand at the undifferentiated (pre-labeling) price, the quantity of environmentally unfriendly production could increase. Their analysis is limited, however, in that it does not account for substitution effects, direct impacts on supply (shifters), changes in marketing costs, or a possible reduction in demand for the environmentally unfriendly product after the eco-label is introduced.

Sedjo and Swallow use a graphical supply and demand model and consider substitution effects. They explore the possibility that a price differential may not arise even when some consumers are willing to pay a premium and identify conditions under which non-certified producers could lose or gain from eco-labeling. Concerned primarily with the effects of eco-certification on price differentials and returns to producers, their analysis does not address effectiveness in terms of changes in production quantities and ultimate environmental impacts.

Swallow and Sedjo consider the effects of eco-labeling in a general equilibrium framework. The authors address the issue of unintended feedback effects, and provide an example that “raises doubts that market changes from certification will lead to large-scale ecological improvement unequivocally” (p. 33). Their graphical analysis is limited to mandatory programs that increase producer costs.

In this chapter, we build on the analysis of Mattoo and Singh, Sedjo and Swallow, and Swallow and Sedjo, and contribute two models that provide a useful framework for anticipating the market interaction effects caused by eco-labeling programs. The main

objective is to identify explicit conditions that determine changes in production quantities and the ultimate environmental impact of certification and labeling. A two-product, partial equilibrium model and a price-endogenous programming model generate equilibrium conditions that provide a basis for comparative static analysis. The GAMS software is used to provide simulation results based on the programming model.

Conceptual Background and Assumptions

We consider the case of a voluntary environmental certification and labeling program designed to protect water quality and preserve water resources in Florida, such as the expanded environmental management practice (EMP) label envisioned for the ornamental plant industry. Leatherleaf ferns serve as an example. The analysis assumes that ferns can be produced using either conventional production methods (without adhering to EMPs) or “green” production methods (in which EMPs are adopted). Conventional fern production methods are known to have negative impacts on water quality, with potential risks for wildlife and human health and the possibility of reducing recreational values and increasing costs of water treatment and supply (Leppla; Larson Vasquez and Nesheim; Stamps). Environmental management practices reduce the risk of negative impacts on Florida water resources (Leppla; Larson Vasquez and Nesheim; Stamps). It is assumed that fern production using EMPs has negligible impacts on water quality.

Producers using EMPs can apply for certification. A certified producer receives public recognition and is entitled to sell ferns bearing an eco-label. We assume that eco-labeled and unlabeled ferns are differentiated in the eyes of the consumer only by the environmental impact of their production methods, a credence attribute. Eco-labeled and unlabeled ferns, therefore, are assumed to be close substitutes in demand and supply.

Oversight and monitoring by a reputable third-party certifying agency are needed to convince consumers of the environmental distinction.

We assume that some producers use green production methods prior to implementation of a certification program. This is not uncommon. For example, some ornamental plant nurseries in Florida report using integrated pest management (IPM) practices even though a certification program is not yet available (Hodges, Aerts, and Neal; Leppla). In terms of the producer model introduced in Chapter 3, these producers have a negative c_g (i.e., green production entails an additional net benefit over standard conventional production costs for the producers that adopt EMPs without obtaining certification or utilizing an eco-label). Also, some producers may advertise their products as environmentally friendly without utilizing an eco-label.

Furthermore, a limited consumer segment may seek out greener products based on producer claims, without relying on an eco-label. For example, farmers market shoppers can talk directly to growers and may trust that their products are organic, pesticide-free, or produced using EMPs without relying on a third-party seal-of-approval.

We assume that ferns produced using EMPs may be sold with or without an environmental claim, but ferns produced without using EMPs cannot be sold with an environmental claim. The possibility of fraud, in which conventionally produced ferns are sold with an environmental claim, is not considered in the models that follow.

Competitive market equilibrium is assumed (i.e., individual consumers and producers act as price takers). Information, however, is imperfect. Certification and labeling serve to improve the information available to producers and consumers. Information that creates non-price incentives for producers is treated separately from

information embodied in an eco-label and directed at consumers. Marketing costs are separated from production costs.

Models of producer and consumer behavior provide insight as to the most likely initial impacts of certification and labeling on supply and demand for the two products. Ultimate changes in production quantities and resulting environmental impacts, however, depend also on the interaction between other market factors, such as pre-labeling conditions, the relationship between own- and cross-price effects, and marketing cost. Next, we formulate a two-product, partial-equilibrium model to identify the effect of eco-labeling on production quantities, considering these market conditions.

Two-Product, Partial-Equilibrium Model

A two-product, partial-equilibrium model is used to understand the interaction between an eco-label's direct effects on supply, demand, and marketing costs, own- and cross-price elasticities of supply and demand, and initial market conditions. For example, when the demand curve shifts by a certain amount (at initial prices), the resulting change in quantity produced is a function of the price elasticities of supply and demand. A demand-side substitution effect occurs, if demand in one market increases as price rises in the market of a close substitute, and vice versa. Supply-side substitution implies that the supply curve in one market shifts in response to price changes in another market.

Based on the consumer and producer models presented in Chapters 2 and 3, the initial impact of introducing an environmental certification and labeling program is represented by a change in the parameter ρ on the demand side, and the parameter ν on the supply side. The parameter ρ is a measure of the credibility of an environmental claim. An increase in ρ is assumed to have a positive impact on demand for the environmentally differentiated good and a negative impact on demand for the unlabeled

good. The parameter v is a proxy for nonprice incentives associated with short- or long-run production costs. An increase in v reduces costs of green production relative to conventional production, increasing green supply and reducing conventional supply, with farm-gate prices held constant.

In addition, the effect of ρ on marketing costs is considered. Improving the credibility of environmental claims through certification and labeling is not without cost. Inspection and monitoring of producers, recordkeeping, and identity preservation through the marketing channel are costly aspects of certification and labeling. Although certification fees are common, they are often paid or subsidized by government or nonprofit organizations. For example, certification rebates have been granted to farmers who obtain organic certification in Europe and the U.S. In the case that certification costs are borne by the market, these expenses could be considered part of the marketing costs associated with distributing and selling to the eco-market. Let M_e represent the average cost of distributing and selling to the eco-market (additional to green production cost), and let M_u represent the cost of distributing and selling to the undifferentiated market (additional to conventional production cost). If adoption of certification and labeling (associated with an increase in ρ) entail costs additional to green production, then the partial derivative of M_e with respect to ρ is positive ($\partial M_e / \partial \rho > 0$).

Departing slightly from the producer model in Chapter 3, we distinguish between farm-gate prices, P_c and P_g (for conventional ferns and “green” ferns, respectively), and retail prices, P_u and P_e (for unlabeled ferns and ferns sold with an eco-label or environmental claim). These prices are considered endogenous in the market equilibrium model. Other endogenous variables are the aggregate production quantities, Q_g

(green) and Q_c (conventional). Production quantities are expressed in retail units. The exogenous variables are ρ and v , representing the information-based effects of credibility for consumers and non-price incentives for producers. All other relevant variables are held constant and omitted from the analysis.

The parameters ρ and v are treated as continuous variables. Treating them as continuous facilitates comparative static analysis, and mathematical system models with continuous flows tend to be more illuminating than those that treat variables as discrete events (Forrester). “Real systems are more nearly continuous than is commonly supposed....A continuous-flow system is usually an effective first approximation even where...discrete decisions and events do occur” (Forrester, p.64-65).

Like negative publicity, advertising intensity, a media event, increased cooperative extension activities, or other information-related changes, the variables ρ and v are not easily quantifiable. They can be estimated, however, *ex ante*, using survey research, or *ex post*, using market data. For example, Teisl, Roe, and Levy use surveys in which consumers are asked to rate the credibility of different labels, and Teisl, Roe, and Hicks measure the impact of the dolphin-safe label on demand for tuna. Teisl and Roe discuss various implications of measuring consumer response to environmental labels.

Comparative static analysis demonstrates how the equilibrium values of endogenous variables, such as production quantities, change as a result of exogenous changes in parameters. In particular, the analysis identifies the direction and rate of change in an equilibrium value of one variable with respect to a change in another. Comparative statics does not provide insight regarding the path, process, or timing of adjustment (Chiang).

If the negative environmental effects of conventional production are significant and the environmental effects of green production and the alternative uses for factors of production are negligible, the environmental impact would be proportional to the change in conventional production. A decline in conventional production would result in an environmental improvement, and an increase in conventional production would cause more environmental harm. Based on this assumption, we focus the subsequent analysis on the effect of eco-labeling on the quantity of conventional production, Q_c . In a later section, a price-endogenous programming model is used to consider alternative assumptions.

Using the partial-equilibrium model, we consider two different market equilibrium scenarios. In the first market scenario, the entire supply of “green” product is sold with an environmental claim (on the “eco-market”) even before an eco-label is introduced. This condition would occur if green supply is small relative to eco-demand. Even a small eco-market (of consumers dedicated to seeking out greener products prior to labeling) is enough to absorb green production and support a “green” producer price at least as high as the conventional producer price. In the second scenario, excess green supply is sold on the undifferentiated market without an environmental claim. This second case suggests that green supply is large relative to eco-demand. The eco-market is not large enough to absorb all the green production, and green producers receive the same farm-gate price whether they sell to the eco-market or the undifferentiated market.

The first scenario is depicted in Figure 4-1. Demand quantity equals supply quantity for each product, and none of the green supply is sold on the undifferentiated market. The producer price equals the retail price minus marketing costs for each market.

Constant returns to scale in marketing are assumed (per unit marketing cost does not change as the quantity marketed changes). The equilibrium conditions for this first scenario are

$$\begin{aligned}
 (4-1) \quad & S_g(P_g, P_c, \nu) - Q_g \equiv 0 \\
 & S_c(P_c, P_g, \nu) - Q_c \equiv 0 \\
 & D_e(P_e, P_u, \rho) - Q_g \equiv 0 \\
 & D_u(P_u, P_e, \rho) - Q_c \equiv 0 \\
 & P_g + M_e(\rho) - P_e \equiv 0 \\
 & P_c + M_u - P_u \equiv 0
 \end{aligned}$$

where S_g and S_c are the green and conventional supply functions, respectively; D_e and D_u are eco- and undifferentiated demand functions, respectively; and M_e and M_u are marketing costs associated with the eco-market and the undifferentiated market, respectively.

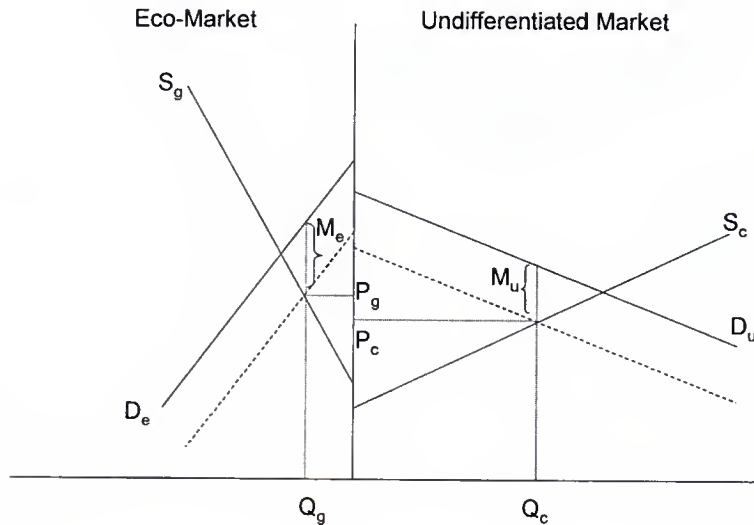


Figure 4-1. First market equilibrium scenario

First considering the effects of eco-label credibility, ρ , on demand and marketing cost, the resulting impact on conventional production is represented by the comparative static derivative, $dQ_c/d\rho$:

$$(4-2) \quad \frac{dQ_c}{d\rho} = + \frac{\frac{[S_{cg} D_{eu} - S_{cc} D_{ee} + S_{gg} S_{cc} - S_{gc} S_{cg}] \frac{\partial D_u}{\partial \rho}}{|J|}}{|J|} + \frac{[S_{cc} D_{ue} - S_{cg} D_{uu}] \frac{\partial D_e}{\partial \rho}}{|J|} + \frac{[D_{ue} (S_{gg} S_{cc} - S_{gc} S_{cg}) - S_{cg} (D_{ee} D_{uu} - D_{eu} D_{ue})] \frac{\partial M_e}{\partial \rho}}{|J|}$$

The mathematical procedures are described in Appendix A. The denominator in Eq. 4-2, represented by $|J|$, is the endogenous variable Jacobian determinant, which is positive in this case. The bracketed numerator terms in Eq. 4-2 are the partial derivatives of supply and demand with respect to own price or the other product's price. For example, S_{gg} is the change in green supply quantity with respect to a change in green producer price ($\partial S_g / \partial P_g$), and S_{gc} is the change in green supply quantity with respect to a change in conventional producer price ($\partial S_g / \partial P_c$). The term D_{uu} is the change in unlabeled demand quantity with respect to a change in unlabeled retail price ($\partial D_u / \partial P_u$), and D_{ue} is the change in unlabeled demand quantity with respect to a change in the retail price for the eco-labeled product ($\partial D_u / \partial P_e$).

It is assumed that supply and demand functions are well-behaved and that the two products are substitutes in supply and demand. Thus, own-price supply responses are positive; cross-price supply responses are negative; own-price demand responses are

negative; and cross-price demand responses are positive. Normal properties of supply and demand imply that own-price effects outweigh cross-price effects. This result follows from the negative semi-definiteness of the substitution matrix. Given these assumptions, the comparative static result in Eq. 4-2 shows that $\partial D_u / \partial \rho$ and $\partial M_e / \partial \rho$ have positive effects on conventional production, Q_c , whereas the effect of $\partial D_e / \partial \rho$ is ambiguous.

The direction of change in conventional production resulting from an increase in eco-demand depends on the sign of the term $S_{cc} D_{ue} - S_{cg} D_{uu}$. If this term is negative, increasing demand for the eco-labeled ferns has a negative effect on conventional production as intended. The term is likely to be negative if the rising green price causes conventional producers to switch to green production (S_{cg} is large), but does not cause many consumers to switch back to undifferentiated consumption (D_{ue} is small). Any increase in marketing costs associated with labeling, however, offsets the effect of increasing eco-demand. Conventional production will fall, only if the negative effect from rising eco-demand outweighs the positive effect of increased marketing costs.

An increase in eco-demand has a positive (unintended) effect on conventional production, if $S_{cc} D_{ue} - S_{cg} D_{uu}$ is positive. The term could be positive if the increase in green price does not induce many conventional producers to switch to green practices (S_{cg} is small), but causes “previously green” consumers to switch to unlabeled consumption (D_{ue} is large). This effect might occur when an eco-label allows access to a foreign market or large segment of consumers that had previously avoided the class of products (ferns from the producing region). The resulting rise in price could induce some “previously green” consumers to buy the unlabeled product instead. An increase in

conventional production caused by the initial impacts of eco-labeling on demand is only possible if the increase in eco-demand is much greater than the decrease in undifferentiated demand (i.e., $|\partial D_e / \partial \rho| > |\partial D_u / \partial \rho|$).

If marketing costs are unchanged and the decrease in undifferentiated demand equals the increase in eco-demand (i.e., $|\partial D_e / \partial \rho| = |\partial D_u / \partial \rho|$), conventional production declines (regardless of the sign of $S_{cc} D_{ue} - S_{cg} D_{uu}$). This result is obtained by comparing the bracketed terms associated with $\partial D_u / \partial \rho$ and $\partial D_e / \partial \rho$ and noting the assumption that own-price effects are larger in absolute value than cross-price effects. The comparative static result, presented in Eq. 4-2, highlights the importance of a decline in undifferentiated demand for reducing conventional production and its harmful environmental impacts.

Now considering the non-price incentives v , which affect supply, the comparative static derivative for the effect on conventional production is

$$(4-3) \quad \frac{dQ_c}{dv} = \frac{[(D_{ee} D_{uu} - D_{eu} D_{ue}) + (S_{gc} D_{ue} - S_{gg} D_{uu})] \frac{\partial S_c}{\partial v} + [S_{cg} D_{uu} - S_{cc} D_{ue}] \frac{\partial S_g}{\partial v}}{|J|}$$

Again, the denominator term $|J|$ is the endogenous variable Jacobian determinant and is positive in sign (Appendix A). Given standard assumptions about supply and demand, the bracketed term in front of $\partial S_c / \partial v$ in Eq. 4-3, $[(D_{ee} D_{uu} - D_{eu} D_{ue}) + (S_{gc} D_{ue} - S_{gg} D_{uu})]$, is positive, and the sign of the bracketed term in front of $\partial S_g / \partial v$, $[S_{cg} D_{uu} - S_{cc} D_{ue}]$, is ambiguous.

The term in front of $\partial S_g / \partial v$ in Eq. 4-3 is the same as the term associated with $\partial D_e / \partial \rho$ in Eq. 4-2, except that the sign is reversed. An increase in green supply due to

nonprice incentives could lead to a rise in conventional production, if falling green prices cause many producers to switch back to conventional methods (S_{cg} is large) but do not cause many consumers to switch to eco-labeled products (D_{ue} is small). This positive effect on conventional production is theoretically possible if many new (and efficient) producers enter fern production ($|\partial S_g / \partial v| > |\partial S_c / \partial v|$), “previously green” growers switch back to conventional production as the green farm-gate price falls. This possibility seems less likely than the previous demand-side case of accessing a new consumer segment. In particular, one would expect demand for unlabeled ferns to decline significantly (and demand for eco-labeled ferns to increase) as the eco-label price falls. This effect would eliminate the possibility that increasing green supply could cause a rise in conventional production.

If the nonprice incentives associated with certification and labeling cause conventional producers to switch to green methods, but do not cause significant entry into the producing sector (i.e., $|\partial S_g / \partial v| = |\partial S_c / \partial v|$), conventional output will decline regardless of the sign of $S_{cg}D_{uu} - S_{cc}D_{ue}$. This result is intuitively clear and can be verified by comparing the bracketed terms in front of $\partial S_c / \partial v$ and $\partial S_g / \partial v$ and by considering the assumption that own-price effects outweigh cross-price effects.

Under this first market equilibrium scenario, our analysis shows that a decrease in undifferentiated demand unambiguously leads to a decline in conventional production. Also, nonprice incentives that cause conventional producers to adopt EMPs (without causing significant entry of new producers into the sector) clearly lead to a decrease in conventional production. The effect of increasing eco-demand on conventional production is less certain and may be positive in some cases. The analysis of this first

market equilibrium scenario indicates that an eco-labeling program will be most effective at reducing conventional production when undifferentiated demand declines significantly, and producers readily convert from conventional to green production in response to price and nonprice incentives.

The second market scenario is depicted in Figure 4-4. Excess green supply is sold on the undifferentiated market, without an environmental claim. In a competitive market, the farm-gate price for the green product equals the farm-gate price for the conventional product, although retail prices may not be the same. In this scenario, total supply (green plus conventional) equals total demand (eco-demand plus undifferentiated demand).

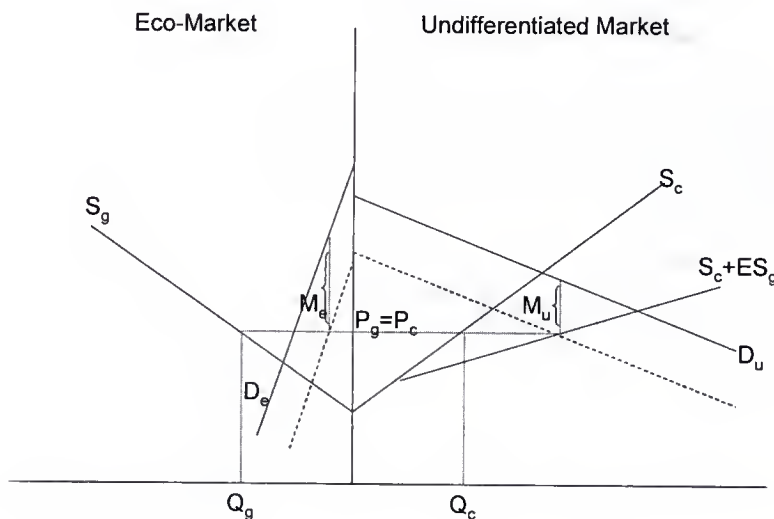


Figure 4-2. Second market equilibrium scenario

Equilibrium conditions for this second scenario are

$$\begin{aligned}
(4-4) \quad & S_g(P_g, P_c, \nu) + S_c(P_c, P_g, \nu) - D_e(P_e, P_u, \rho) - D_u(P_u, P_e, \rho) \equiv 0 \\
& S_g(P_g, P_c, \nu) - Q_g \equiv 0 \\
& S_c(P_c, P_g, \nu) - Q_c \equiv 0 \\
& P_g + M_e(\rho) - P_e \equiv 0 \\
& P_c + M_u - P_u \equiv 0 \\
& P_g + M_u - P_u \equiv 0
\end{aligned}$$

Again considering the effect of improved credibility from the eco-label, ρ , on the quantity of conventional production, Q_c , the comparative static result is shown in Eq. 4-5:

$$(4-5) \quad \frac{dQ_c}{d\rho} = \frac{[S_{cc} + S_{cg}] \left(\frac{\partial D_e}{\partial \rho} + \frac{\partial D_u}{\partial \rho} \right) + [(D_{ee} + D_{ue})(S_{cc} + S_{cg})] \frac{\partial M_e}{\partial \rho}}{(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})}$$

The mathematical derivation is provided in Appendix A.

Assuming own-price effects are larger than cross-price effects (in absolute value), the denominator of Eq. 4-5 is positive. The bracketed numerator term in front of $\partial D_e / \partial \rho$ and $\partial D_u / \partial \rho$, $[S_{cc} + S_{cg}]$, is positive, and the bracketed term in front of $\partial M_e / \partial \rho$, $[(D_{ee} + D_{ue})(S_{cc} + S_{cg})]$, is negative. In this scenario, the effect of decreasing demand for the undifferentiated product is exactly offset by an increase in eco-demand. In other words, if the increase in eco-demand equals the decrease in undifferentiated demand (i.e., $|\partial D_e / \partial \rho| = |\partial D_u / \partial \rho|$) conventional production quantity will not change, *ceteris paribus*. On the other hand, if eco-demand rises more than undifferentiated demand falls (i.e., total demand increases and $|\partial D_e / \partial \rho| > |\partial D_u / \partial \rho|$), and marketing costs are unaffected, conventional production will increase. This result is the same as the one obtained by Mattoo and Singh. The simple condition that some green supply is sold on the undifferentiated market prior to labeling creates a strong likelihood that eco-labeling will result in an increase in conventional production. Opposite from the first market equilibrium scenario, an increase in marketing costs associated with labeling reduces

conventional production in this case. Considering the total effect of an increase in ρ , we conclude that conventional production will increase if total farm-gate demand (after accounting for any change in marketing cost) rises.

Nonprice incentives affecting supply result in the following impact on conventional production:

$$(4-6) \quad \frac{dQ_c}{d\nu} = \frac{\partial S_c}{\partial \nu} + \frac{[-(S_{cc} + S_{cg})] \left(\frac{\partial S_g}{\partial \nu} + \frac{\partial S_c}{\partial \nu} \right)}{(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})}.$$

As in Eq. 4-5, the denominator in Eq. 4-6 is positive, assuming well-behaved demand and supply functions. The numerator term associated with $\partial S_g / \partial \nu$ in Eq. 4-6 is negative, and the combined effect associated with $\partial S_c / \partial \nu$ is positive. This result clearly shows that any nonprice incentives that increase green supply and decrease conventional supply will reduce the quantity of conventional production. In other words, programs that disseminate information about cost-reducing methods of green production or provide other types of nonprice incentives lead to an unambiguous reduction in conventional production.

Results generated by the two-product, partial-equilibrium model are summarized in Table 4-1. An increase in eco-demand is not the best indication of an eco-labels effectiveness at reducing environmental impacts associated with production. In fact, when the increase in farm-gate green demand (after accounting for marketing costs) exceeds any decrease in farm-gate demand for the undifferentiated product, conventional production and environmental harm may rise. Under the assumption that negative environmental impacts are positively related to conventional production quantities, decreases in demand for the undifferentiated product and nonprice incentives that

encourage conventional growers to adopt green practices are most effective at protecting the environment in the producing region.

Table 4-1. Two-product, partial-equilibrium model results

Initial impact	Market conditions	Effect on Q_c
$\partial D_e / \partial \rho > 0$ and $\partial D_u / \partial \rho < 0$	1 st scenario: no excess green supply	
	$ \partial D_e / \partial \rho = \partial D_u / \partial \rho $	Negative
	$ \partial D_e / \partial \rho > \partial D_u / \partial \rho $	
	$S_{cc}D_{ue} > S_{cg}D_{uu}$	Ambiguous
	$S_{cc}D_{ue} < S_{cg}D_{uu}$	Negative
	2 nd scenario: excess green supply	
	$ \partial D_e / \partial \rho = \partial D_u / \partial \rho $	No change
	$ \partial D_e / \partial \rho > \partial D_u / \partial \rho $	Positive
$\partial S_g / \partial v > 0$ and $\partial S_c / \partial v < 0$	1 st scenario: no excess green supply	
	$ \partial S_g / \partial v = \partial S_c / \partial v $	Negative
	$ \partial S_g / \partial v > \partial S_c / \partial v $	
	$S_{cc}D_{ue} > S_{cg}D_{uu}$	Negative
	$S_{cc}D_{ue} < S_{cg}D_{uu}$	Ambiguous
	2 nd scenario: excess green supply	Negative
$\partial M_e / \partial \rho > 0$	1 st scenario: no excess green supply	Positive
	2 nd scenario: excess green supply	Negative

Price-Endogenous Programming Model

In this section, a price-endogenous programming model is used to simulate the effects of introducing an eco-label on land-use and the environment in a producing region. Price-endogenous programming models allow simulation of market responses to changes in policies or economic circumstances (McCarl and Spreen; Hazell and Norton). In particular, they are useful for anticipating the impact of the introduction of new

technologies or market opportunities, for which historical data is not available (McCarl and Spreen; Hazell and Norton).

Final demand schedules, input supply curves, and intermediate costs are necessary for building a price-endogenous programming model. Input demands and output supplies are implicit in the model. Typically in price-endogenous models, demand curves for final commodities are specified based on elasticities estimated from historical market data. In the case of introducing an eco-label, a new differentiated product, market data is not available to estimate a demand function. Instead survey data can be used to provide estimates of consumer response and demand for a new product.

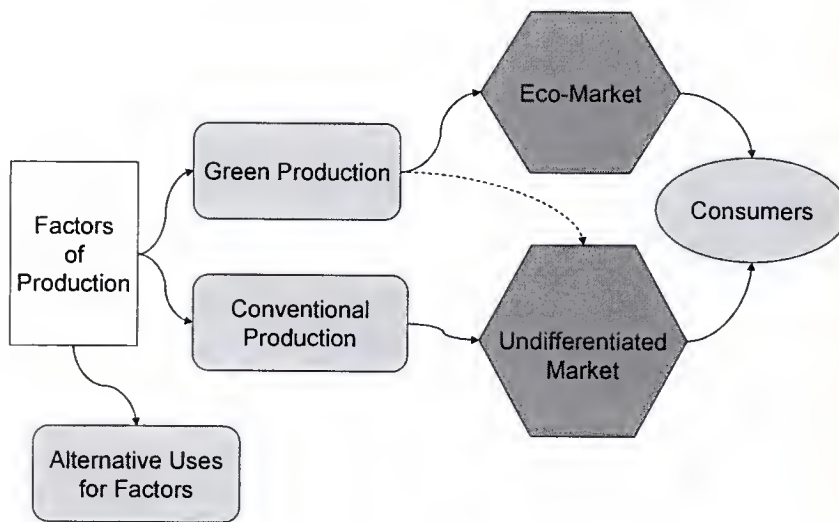


Figure 4-3. Conceptual diagram of the price-endogenous model

We consider the example of introducing an EMP certification and labeling program for ornamental nursery plants, such as leatherleaf ferns, in Florida. In this model, land in Florida's ornamental plant producing regions may be used for three mutually exclusive

alternatives: conventional fern production, “green” fern production (using EMPs), or a next best alternative (e.g., housing development or another agricultural crop).

Conventional ferns are sold unlabeled (on the undifferentiated market). “Green” ferns may be sold with an eco-label (on the eco-market), or without an eco-label (on the undifferentiated market). A conceptual diagram of the sector is shown in Figure 4-3.

A first step in building the model would be to estimate relevant final demand curves. We consider three types of consumers, similar to the types introduced in Chapter 2. Consumer Type A currently purchases Florida-grown ferns, but would not pay any premium for an eco-label. Consumer Type B currently purchases Florida ferns and would purchase them with an eco-label at some positive premium if she had the option. Consumer Type C does not currently purchase Florida ferns, but would consider buying them if they were eco-labeled. This last type of consumer might be in an export market that requires an eco-label for importation. Consumer Type C could also represent a serious environmentalist who avoids products that he perceives as harmful to the environment. Demand from these three consumer groups could be segmented as follows.

Estimates of current demand (prior to introducing eco-label) for Florida ferns are available from existing market data. Let the inverse form of this demand function be denoted by $P_z(Z)$, where P_z is the price of unlabeled ferns, and Z is the quantity of unlabeled ferns sold. This demand schedule from consumer Types A and B represents implicit demand for the private fern characteristic plus implicit demand for the environmental impact (a negative value). This explanation is compatible with the theory and consumer model presented in Chapter 2. The inverse demand for unlabeled ferns corresponds to Eq. 2-22.

To estimate the new demand created by introducing an eco-label, consumer surveys would be necessary. In particular, a contingent valuation spike model similar to the one used by Jensen and Jakus would be appropriate. Targeted at current consumers of Florida leatherleaf ferns, the survey would first identify those consumers willing to pay a nonzero premium for ferns bearing the EMP eco-label (i.e., consumer Type B, referred to as eco-consumers). Then a distribution function could be estimated that relates the level of the price premium to the fraction of eco-consumers willing to purchase the eco-labeled ferns at that price premium. If we unit demand is assumed (i.e., quantity units are expressed as a fixed amount of ferns purchased by each consumer), the number of consumers willing to purchase at a given premium is equal to the quantity of eco-labeled ferns demanded (in the per-consumer units). Otherwise the distribution function could be adjusted to account for variation in quantities purchased among eco-consumers. This method of estimating demand for quality corresponds to Tirole's model (pp. 96-97) presented in Chapter 2.

Based on our model presented in Chapter 2, it is known that consumers already purchasing ferns at the market price will purchase the eco-labeled ferns if their marginal utility from the eco-label attribute relative to their marginal utility of income exceeds the price premium. For the consumer at the margin, indifferent between choosing the eco-labeled and the unlabeled ferns at a given price premium, Eq. 2-24 must hold with equality. This equation is restated here as

$$(4-7) \quad -\rho \frac{U_B}{U_Y} = P_r.$$

Similar to Tirole's model, the distribution function, $F(P_r/\rho)$, represents the portion of eco-consumers unwilling to pay a price premium of size P_r , for the eco-attribute represented

by a particular label with a level of credibility represented by ρ . For a given eco-label (ρ is fixed), the distribution function would relate demand to the price premium, P_r . The price premium equals the difference between the eco-labeled price and the unlabeled price of ferns (i.e., $P_e - P_u$). The distribution function is shown in Figure 4-4.

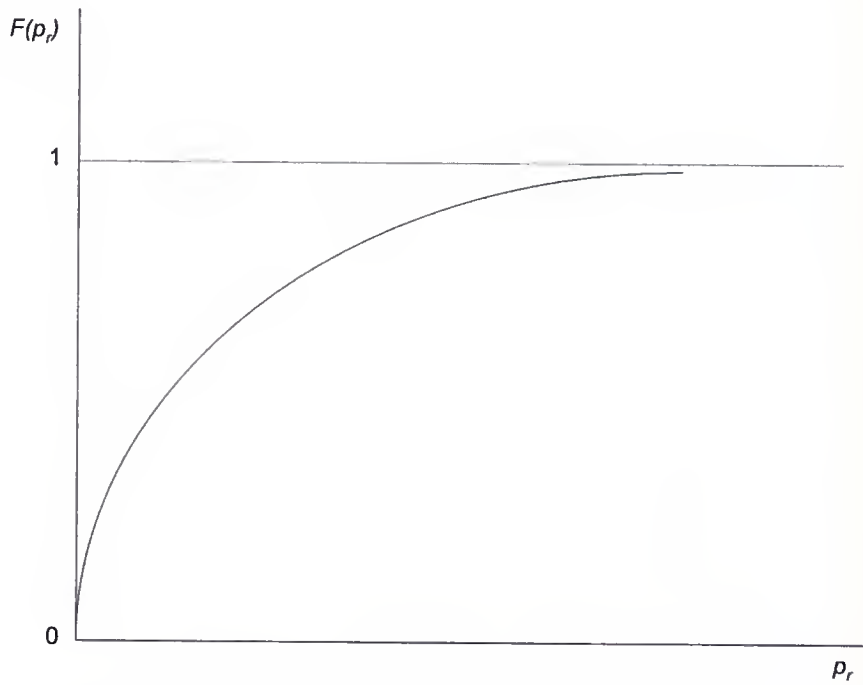


Figure 4-4. Distribution function representing willingness to pay a premium for eco-label

The ordinary unit demand for the eco-attribute is given by

$$(4-8) \quad D_e\left(\frac{P_r}{\rho}\right) = N_e \left[1 - F\left(\frac{P_r}{\rho}\right) \right]$$

and the inverse demand is

$$(4-9) \quad P_r(E) = \rho F^{-1}\left(1 - \frac{E}{N_e}\right)$$

where N_e is the entire eco-consumer segment (those current fern consumers willing to pay a nonzero premium for the eco-attribute), and E is the quantity of eco-labeled ferns

demanded at premium P_r . In this formulation, demand for the eco-attribute is expressed as a function of the label's credibility represented by the credibility parameter ρ . If inverse demand for the eco-attribute with perfect credibility is $P_E(E)$, then the inverse demand function representing an eco-label with less than perfect credibility is

$$(4-10) \quad P_r(E) = \rho P_E(E).$$

This demand function for the eco-characteristic could be used in a price-endogenous programming model, together with the existing demand function for ferns without the eco-label, $P_z(Z)$.

A novel aspect of the model presented here is that final demand (by consumer Types A and B) is represented by demand for characteristics schedules, instead of demand for final goods. This approach has practical advantages (allows incorporation of demand for a new characteristic, estimated using survey data) and is consistent with the branches of consumer theory described in Chapter 2. As described by Ladd and Suvannunt (p. 504)

For each product consumed, the price paid by the consumer equals the sum of the marginal monetary values of the product's characteristics; the marginal monetary value of each characteristic equals the quantity of the characteristic obtained from the marginal unit of the product consumed multiplied by the marginal implicit price of the characteristic....

Ladd and Suvannunt (p. 505) state that "total consumption of each characteristic can be expressed as a function of quantities of products consumed and of consumption input-output coefficients." These statements suggest a model in which final demand for characteristics (marginal implicit price schedules), such as $P_E(E)$, can be filled by products (eco-labeled ferns) in proportion to the amount of a characteristic perceived in a product (represented by the coefficient ρ). Equation 4-10 shows this relationship.

Certain aspects of this approach, such as possible interaction effects between multiple characteristics bundled together in a single product, create difficulties. Also, the demand specification presented above does not consider possible effects of changes in price of the base characteristic on demand for the eco-attribute, and vice versa. If it is assumed that utility is separable and of the Cobb-Douglas form, however, demand for one characteristic would be independent of other characteristics (Silberberg and Suen). It could be argued that substitution effects between characteristics would be weak or negligible. Intuitively, there may be good reasons to assume that two closely related products, such as eco-labeled ferns and unlabeled ferns, are substitutes. Substitution effects between demand for characteristics (such as enjoyment of ornamental plants and water quality), however, are intuitively weaker. Therefore, ignoring substitution effects between these characteristics schedules does not appear to pose a major shortcoming. Also, interaction effects between different characteristic bundles would be minimal, since only two characteristics are considered in this model. Such interaction effects might present a more significant problem, if several characteristics were contained in the model.

Finally, the potential demand among consumers not purchasing Florida ferns prior to eco-labeling (consumer Type C) is considered. We call this consumer segment Market 2, to distinguish it from the demands estimated previously (Market 1). Market 2 could represent an export market. Using survey data or other methods, the demand for eco-labeled ferns (with the combined characteristics Z and E) could be estimated for Market 2. In inverse form, this demand function is represented by $P_2(ZE_2)$. We assume that the demand function in Market 2 is independent of prices in Market 1.

These three demand schedules enter the objective function of the quadratic program. Other value and cost schedules in the objective function include, a value function representing demand for land in its next best alternative use (to fern production), per acre production costs, and marketing costs. Land is a shared input required for both types of fern production and the next best alternative. The variables, X_C , X_G , X_A , are the acreage employed in conventional fern production, “green” fern production, and the alternative land use respectively. The alternative land value, represented by $V_A(X_A)$, is a decreasing function of the amount of land allocated to the alternative uses. Hypothetical direct per acre production cost schedules, $C_C(X_C)$ and $C_G(X_G)$, are formulated for conventional and “green” ferns. These cost schedules are increasing functions of the amount of land allocated to each activity. Direct inputs are assumed unique to each production method, allowing the direct cost schedule for each of the production methods to be independent of production quantities of the other. This simplifying assumption is fairly strong, since in reality conventional production shares many of the same inputs with production using EMPs. Per unit marketing costs for each market, C_1 and C_2 , include all intermediate costs between production and the final consumer. Per unit marketing costs are assumed constant. Additional to the standard marketing costs, certification and labeling costs must be incurred for products sold on the eco-market. These costs are represented by $C_{E1}Y_{GE1}$ and $C_{E2}Y_{GE2}$, where C_E is a per unit cost and Y_{GE} is the quantity of green production allocated to eco-labeling for each market. It is assumed that C_E includes both c_t (certification costs) and c_e (eco-label marketing costs) described in the producer model in Chapter 3. The objective function of the price-endogenous programming model simulates a competitive equilibrium:

$$(4-11) \quad \begin{aligned} & \text{Max} \int P_{Z1}(Z_1)dZ_1 + \rho \int P_{E1}(E_1)dE_1 + L_2 \int P_2(ZE_2)dZE_2 + \int V_A(X_A)dX_A \\ & - \int C_c(X_C)dX_C - \int C_G(X_G)dX_G - C_1Z_1 - C_2ZE_2 - L_1C_{E1}Y_{GE1} - L_2C_{E2}Y_{GE2} \end{aligned}$$

where L_1 and L_2 are zero-one variables indicating whether an eco-label has been introduced to Market 1 or 2 respectively. The set of constraints for the price-endogenous programming model is

$$(4-12) \quad \begin{aligned} & X_C + X_G + X_A \leq X \\ & Y_C - y_c X_C \leq 0 \\ & Y_G - y_g X_G \leq 0 \\ & Y_{GU} + Y_{GE1} + Y_{GE2} - Y_G \leq 0 \\ & Z_1 - Y_{GU} - Y_{GE1} - Y_C \leq 0 \\ & E_1 - Y_{GE1} \leq 0 \\ & ZE_2 - Y_{GE2} \leq 0 \\ & EI_C X_C + EI_G X_G + EI_A X_A = EI_T \end{aligned}$$

Constraints require that land allocated to the three alternatives is less than or equal to the total land available in the producing region, X . Conventional fern output, Y_C , must be less than or equal to the number of acres in conventional production times the average per acre yield, y_c . The same constraint applies to green fern output and per acre yield, Y_G and y_g . Green output may be divided between green-unlabeled, Y_{GU} , eco-labeled product on Market 1, Y_{E1} , and eco-labeled product on market 2, Y_{E2} . Current fern demand, Z_1 , is filled by the sum of conventional output, green unlabeled output, and eco-labeled output placed on Market 1. Demand for the eco-attribute in Market 1 can only be filled by eco-labeled product sent to Market 1, and demand for eco-labeled ferns on market 2 is filled by green, eco-labeled product sent to Market 2. Additionally, an accounting row is added that calculates the total environmental impact, EI_T , (e.g., an index of effluent run-off or water quality impacts) as a function of the amount of land in each activity and the per acre environmental impacts associated with the three alternatives, EI_C , EI_G , and EI_A .

Differentiating the Lagrangian for the model, one obtains market equilibrium conditions. Assuming $X_C, X_G, X_A, Z_I, E_I > 0$ and $ZE_2 = 0$, a necessary condition for land allocation equilibrium is

$$(4-13) \quad V_A = y_c(P_{Z_I} - C_1) - C_C = y_g(P_{Z_I} - C_1 + \rho P_{E_I} - C_{E_I}) - C_G$$

Land is allocated so that the per acre value obtained from conventional ferns sold unlabeled equals the per-acre value obtained from green ferns sold with an eco-label.

Land values from either type of fern production equal the value of an acre of land in its next best alternative use, V_A . The introduction of an eco-label, represented by an increase in the parameter ρ , increases the effective demand for green ferns and the value of an acre of land producing ferns using EMPs. In the long-run, green acreage increases, while conventional fern acreage and alternative land-uses decline until equilibrium is restored.

Assuming $X_G, Z_I, E_I > 0$, and green ferns are sold both eco-labeled and unlabeled, market equilibrium for green fern output requires that

$$(4-14) \quad V_A + C_G = y_g(P_{Z_I} - C_1 + \rho P_{E_I} - C_{E_I}) = y_g(P_{Z_I} - C_1).$$

The opportunity cost of land plus the direct per acre production cost using green methods equals the value of an acre's yield sold either labeled or unlabeled. This scenario implies that all the "eco-label rents" are exhausted, and $\rho P_{E_I} = C_{E_I}$. Only if the price premium no longer exceeds the additional marketing costs associated with certification and labeling, and conventional ferns are no cheaper to produce, will ferns produced using EMPs be sold unlabeled.

Producers will only sell ferns with an eco-label, if the following price equilibrium condition holds:

$$(4-15) \quad P_{Z1} + \rho P_{E1} = \frac{1}{y_g}(V_A + C_G) + C_1 + C_{E1}$$

The left-hand side of Eq. 4-15 is the sum of the implicit characteristic values each multiplied by its associated coefficient. This sum equals the market price for eco-labeled ferns. This result is consistent with the consumer models described by Gorman, Michael and Becker, Ladd and Suvannunt, and Stigler and Becker, and is similar to Eqs. 2-2, 2-8, 2-11, and 2-14. The right-hand side of Eq. 4-15 is the sum of all costs associated with producing and marketing a unit of eco-labeled ferns.

A complete set of necessary first-order conditions can be generated for the price – endogenous programming model under the two different scenarios considered for the previous model. If green supply is fully absorbed by green demand (i.e., no green output is sold on the undifferentiated market), the equilibrium conditions are

$$(4-16) \quad \begin{aligned} y_c P_{Z1}(Z_1) - y_c C_1 - C_C(X_C) - V_A(X_A) &\equiv 0 \\ y_g P_{Z1}(Z_1) - y_g C_1 - C_G(X_G) - V_A(X_A) + \rho y_g P_{E1}(E_1) - y_g C_{E1} &\equiv 0 \\ L_2 y_g P_2(ZE_2) - y_g C_2 - C_G(X_G) - V_A(X_A) &\equiv 0 \\ X_A + X_C + X_G - X &\equiv 0 \\ Z_1 + ZE_2 - y_g X_G - y_c X_C &\equiv 0 \\ E_1 + ZE_2 - y_g X_G &\equiv 0 \end{aligned}$$

In Eq. 4-16, eco-labeling costs associated with Market 2 are included in C_2 . When eco-labeling does not provide access to a new consumer market (Market 2), $L_2 = 0$, $ZE_2 = 0$, and the third identity in Eq. 4-16 does not apply. If green supply exceeds green demand at given prices (i.e., some green output is sold on the undifferentiated market), the equilibrium conditions are

$$\begin{aligned}
& y_c P_{Z1}(Z_1) - y_c C_1 - C_C(X_C) - V_A(X_A) \equiv 0 \\
& y_g P_{Z1}(Z_1) - y_g C_1 - C_G(X_G) - V_A(X_A) \equiv 0 \\
& y_g P_{Z1}(Z_1) - y_g C_1 - C_G(X_G) - V_A(X_A) + \rho y_g P_{E1}(E_1) - y_g C_{E1} \equiv 0 \\
(4-17) \quad & L_2 y_g P_2(ZE_2) - y_g C_2 - C_G(X_G) - V_A(X_A) \equiv 0 \\
& X_A + X_C + X_G - X \equiv 0 \\
& Z_1 + ZE_2 - y_g X_G - y_c X_C \equiv 0 \\
& E_1 + ZE_2 + Y_{GU} - y_g X_G \equiv 0
\end{aligned}$$

Again, eco-labeling costs for Market 2 are included in C_2 . When eco-labeling does not provide access to a new consumer market (Market 2), $L_2 = 0$, $ZE_2 = 0$, and the fourth identity in Eq. 4-17 drops out.

Comparative static analysis can be conducted to identify the direction of change in the land-use variables X_C , X_G , and X_A resulting from changes in the parameters ρ and L_2 , or from changes in cost parameters. Instead, however, we create a parameterized version of the model using General Algebraic Modeling System (GAMS) software and run the model to simulate effects under different market conditions. The GAMS program shown in Appendix B is calibrated so that $\rho = 0.5$ and Market 2 is not accessible. The value of ρ is built into the shifter parameter on the demand for E_1 . The shift parameters adjust the units, so that demand quantities are expressed in millions of boxes and land units are in thousands of acres.

As with the two-product, partial equilibrium model, two different initial market scenarios are considered. The first scenario has green production small relative to conventional production. The second scenario has green production acreage large relative to conventional acreage, and excess green supply is sold undifferentiated. Two different cases are considered in terms of the relative environmental impacts of the three land-use alternatives. In the first case, the next best alternative land-use is

environmentally superior to either type of fern production. In the second case, the next best alternative land use is environmentally inferior to either type of fern production.

Three sets of parameters are varied to simulate the effects of developing an environmental certification and labeling program. First, the parameter ρ is varied at intervals between zero and one to simulate the effect of improving the information and credibility associated with the environmental claim in Market 1. Second, with ρ set at 0.5, the parameter, L_2 , is changed from zero to one to represent the opening of the export market to eco-labeled ferns. Third, with $\rho = 0.5$ and $L_2 = 0$, green production costs are reduced to simulate the effect of increasing information to producers on how to use green methods cost effectively. The model is run seven times (columns A-G in Tables 4-2 and 4-3) for each initial market scenario. Table 4-2 lists the results under the first initial market scenario (green production is small relative to conventional production prior to introduction of the certification and labeling program).

Environmental scores listed in the last two rows of Tables 4-2 and 4-3 are calculated based on a hypothetical environmental (water quality) index, EI , between 0 and 1 per thousand acres for each type of land use. The index $EI = 1$ indicates that the land-use has no negative environmental impact, and $EI = 0$ implies the worst possible environmental impact. In other words, the higher the environmental score, the better from an environmental perspective. Conventional fern acreage is assigned an environmental impact value of $EI = 0.3$, and fern acreage under EMPs is assigned an environmental value of $EI = 0.7$. The alternative land-use is assigned a value of $EI = 1$ for the superior alternative case, and $EI = 0$ for the inferior alternative case. We do not

consider an intermediate case, in which the environmental score of the alternative land-use falls between conventional fern production and green fern production.

Table 4-2. Price-endogenous programming model results under 1st market scenario

Parameters	A	B	C	D	E	F	G
ρ	0	0.2	0.5	0.8	1	0.5	0.5
L_2	0	0	0	0	0	1	0
Green production cost	initial	initial	initial	initial	initial	initial	reduced
Variables							
Unlabeled Fern Sales (millions of boxes)	26.119	23.018	22.799	22.731	22.708	22.112	22.705
Ecolabeled Fern Sales1 (millions of boxes)	0.000	3.165	3.396	3.467	3.492	2.949	3.592
Ecolabeled Fern Sales2 (millions of boxes)	0.000	0.000	0.000	0.000	0.000	4.444	0.000
Convent. Fern Acreage (thousands of acres)	69.241	65.766	65.139	64.947	64.879	63.178	59.615
Green Fern Acreage (thousands of acres)	6.283	10.550	11.320	11.556	11.639	24.644	18.104
Alternative Acreage (thousands of acres)	24.476	23.684	23.541	23.497	23.481	12.178	22.281
Environmental Score (Alternative Superior)	49.65	50.80	51.01	51.07	51.09	48.38	52.84
Environmental Score (Alternative Inferior)	25.17	27.11	27.47	27.57	27.61	36.20	30.56

In Table 4-2, Column A lists the initial values of relevant variables and parameters prior to labeling. Columns B through E list the results of increasing ρ incrementally, representing introduction of an eco-label and improved credibility and consumer acceptance in Market 1. Eco-labeled fern sales increase from 0 to 3.5 million boxes, while unlabeled fern sales decline from 26.1 million to 23.7 million boxes. Total fern sales increase. Green fern acreage rises from 6.3 to 11.6 thousand acres, and

conventional fern acreage declines from 69.2 to 64.9 thousand acres. Total fern acreage increases and the alternative land-use declines slightly. Whether or not the alternative land-use is environmentally inferior or superior, the total environmental score improves, although the improvement is less substantial in the superior-alternative case. Because of the way the model is calibrated, the environmental improvement owing to conversion from conventional to green management outweighs any negative environmental impacts associated with the decline in the environmentally superior alternative. The net environmental impact could have been negative in the superior-alternative case, if the model were calibrated differently.

The effect of accessing the new export market can be observed by comparing Column F to Column C in Table 4-2. Sales of unlabeled ferns decline. Eco-labeled fern sales increase, although the amount of eco-labeled product allocated to market 1 decreases. Total fern sales increase substantially. Conventional fern acreage declines, while green fern acreage increases and the alternative land use decreases significantly. In the case that the alternative land-use is environmentally inferior, improvement in the environmental score is considerable. In the case that the alternative land use is environmentally superior, the environmental score worsens. The actual environmental effect in the superior-alternative case depends on model parameterization.

The effect of reducing green production costs (equivalent to increasing green supply at a given price) can be observed by comparing Column G to Column C. Eco-labeled fern sales rise as a result. A large shift in acreage from conventional to green production occurs, and acreage in the alternative land-use falls. The environmental score

improves regardless of the environmental impact of alternative land uses. Again, however, the improvement depends on model calibration in the superior-alternative case.

Table 4-3. Price-endogenous programming model results under 2nd market scenario

Parameters	A	B	C	D	E	F	G
ρ	0	0.2	0.5	0.8	1	0.5	0.5
L_2	0	0	0	0	0	1	0
Green production cost	initial	initial	initial	initial	initial	initial	reduced
Variables							
Unlabeled Fern Sales (millions of boxes)	24.936	21.356	21.344	21.341	21.340	19.840	22.074
Ecolabeled Fern Sales1 (millions of boxes)	0.000	3.580	3.592	3.595	3.596	3.592	3.592
Ecolabeled Fern Sales2 (millions of boxes)	0.000	0.000	0.000	0.000	0.000	4.539	0.000
Convent. Fern Acreage (thousands of acres)	32.407	32.407	32.407	32.407	32.407	35.770	24.482
Green Fern Acreage (thousands of acres)	45.312	45.312	45.312	45.312	45.312	51.506	56.991
Alternative Acreage (thousands of acres)	22.281	22.281	22.281	22.281	22.281	12.724	18.527
Environmental Score (Alternative Superior)	63.72	63.72	63.72	63.72	63.72	59.51	65.77
Environmental Score (Alternative Inferior)	41.44	41.44	41.44	41.44	41.44	46.79	47.24

Results of model runs under the second market scenario (i.e., green fern production is large relative to conventional production, and excess green supply is sold undifferentiated) are shown in Table 4-3. Initial levels of the relevant parameters and variables are listed in Column A. Columns B through E show the effect of introducing the eco-label in market 1, compared to initial values in Column A. Interestingly, despite eco-labeled fern sales increasing from zero to 3.596 million boxes, total fern production

and acreage in the three alternatives do not change. Since land use does not change, there is no change in the environmental score. This result can be explained as follows. Green production prior to labeling exceeds total eco-demand even at a premium just covering additional marketing costs. Eco-labeled ferns are supplied (marketed) up to the point where the premium just covers labeling costs and all “eco-label” rents are exhausted without affecting the “marginal” green producer. Since the “marginal” producer (indifferent between using land for green production, conventional production, or an alternative land use) is unaffected, the land allocation and consequent environmental score will not change. If the increase in demand due to eco-labeling is not sufficient to affect the marginal producer, eco-labeling will have no environmental impact.

The effect of accessing the export market with eco-labeled ferns is seen by comparing Column F to Column C. In this case the increase in total eco-demand is sufficient to affect the marginal producer and additional acreage is converted to green fern production from alternative land-uses. Interesting in this case is that conventional fern acreage rises as well. This effect is the one described by Mattoo and Singh. Green fern output which had been filling some of the unlabeled demand as well as eco-demand in Market 1, now has access to a high-valued export market. This new outlet pulls fern supply away from Market 1 causing the price of ferns in Market 1 to rise. The higher price in Market 1 leads to an increase in conventional production. The result is a worse environmental score if the alternative land use is superior, and a better environmental score if the alternative land use is inferior.

The final case considers the effect of decreasing green production costs relative to conventional production costs under this second market scenario. Comparing Column G

with Column C, one sees that green fern acreage rises, while conventional fern acreage and alternative land-uses decline. Interestingly, eco-labeled fern sales remain constant, but unlabeled fern sales increase. As described previously, when “eco-label rents” are exhausted, some green fern output is sold unlabeled on the undifferentiated market. A reduction in green production costs has the effect of increasing total fern supply and the amount of green ferns sold undifferentiated, but does nothing to increase sales of eco-labeled ferns. The environmental score improves in both alternative land-use cases. Once again, however, the environmental effect depends on model calibration, when the next best land-use is environmentally superior to either fern production method.

Table 4-4. Summary of price-endogenous programming model results

Initial impact	Market conditions	Effect on land-use			Effect on environment
		X_C	X_G	X_A	
$\Delta p > 0$	1 st scenario: no excess green supply	Neg.	Pos.	Neg.	
	Superior alternative land-use				Ambiguous
	Inferior alternative land-use				Positive
	2 nd scenario: excess green supply				
	No new market access ($L_2 = 0$)	No Δ	No Δ	No Δ	No change
	New market access ($L_2 > 0$)	Pos.	Pos.	Neg.	
	Superior alternative land-use				Negative
	Inferior alternative land-use				Positive
$\Delta C_g < 0$	1 st scenario: no excess green supply	Neg.	Pos.	Neg.	
	Superior alternative land-use				Ambiguous
	Inferior alternative land-use				Positive
	2 nd scenario: excess green supply	Neg.	Pos.	Neg.	
	Superior alternative land-use				Ambiguous
	Inferior alternative land-use				Positive

Results from the price-endogenous programming model are summarized in Table 4-4. These results coincide with the ones produced by the two-product, partial equilibrium model. The programming model, however, makes explicit the effects on alternative land-uses and ultimate connection to environmental quality.

When the alternative land-use is environmentally inferior, any increase in green demand ($\Delta p > 0$) or increase in green supply ($\Delta C_g < 0$) leads to an improvement in environmental quality, except under one condition. The exception occurs when excess green supply is sold undifferentiated and the increase in green demand equals the decrease in unlabeled demand. In that case, there will be no change in land-use or environmental impacts from eco-labeling.

When the alternative land-use is environmentally superior, the effects of eco-labeling are generally ambiguous, except under one condition. That condition occurs when excess green supply is sold undifferentiated, and the increase in green demand is much larger than the decrease in undifferentiated demand (e.g., when opening a new market). In that case, the net environmental effect is clearly negative.

The simulation results from the programming model validate the conclusions from the two-product, partial-equilibrium model. The programming model, however, highlights the importance of competing alternative uses for land (or other major shared inputs). An understanding of next best alternative land-uses and their relative environmental impacts is critical for anticipating the ultimate environmental effects of eco-labeling. Although market interactions do result in nuanced effects under different market conditions, a key factor that determines environmental effectiveness is the relative environmental impact of competing land-uses. In particular, when the competing alternative use for land is environmentally inferior to either conventional or green production, any rise in total demand associated with eco-labeling will have a positive environmental impact under all market conditions. However, when the competing

alternative land-use is environmentally superior, eco-labeling may cause a net deterioration in environmental quality.

Summary of Environmental Effects

In this analysis, we assume that the initial impacts of developing voluntary certification and labeling programs are an increase in demand for the greener product, a decrease in demand for its unlabeled (but otherwise identical) counterpart, and nonprice incentives that increase green supply relative to conventional supply. We use a two-product, partial equilibrium model and a price-endogenous programming model to determine the effects of eco-labeling on production quantities, land-use, and the environment. The effectiveness of a voluntary environmental labeling program at improving environmental quality is sensitive to various market conditions and the relative environmental impacts of competing land-use alternatives. Continuing with the example of leatherleaf ferns, we state conditions and draw conclusions based on our model results, which are summarized in Tables 4-1 and 4-4.

Five conditions critical to our analysis are

Condition 1. *Production of an agricultural product, using either conventional or EMP (green) methods, competes with alternative land-uses in the producing region; and either (a) an environmental quality index ranks EMP production higher than conventional production, and ranks the primary alternative land-use lower than conventional production (i.e., the alternative land-use is environmentally inferior to either type of fern production); or (b) an environmental quality index ranks conventional production lower than EMP production, and ranks the primary alternative land-use higher than EMP production (i.e., the alternative land-use is environmentally superior to either type of fern production).*

Condition 2. *Output from EMP production may be sold either on the eco-market with an eco-label or on the undifferentiated market without an eco-label; and either (a) no excess green supply is sold on the undifferentiated market, or (b) excess green supply is sold on the undifferentiated market.*

Condition 3. *The eco-labeled and unlabeled ferns are substitutes in both demand and supply; and either (a) $S_{cc}D_{ue} > S_{cg}D_{uu}$ or (b) $S_{cc}D_{ue} < S_{cg}D_{uu}$; where S_{ii} is an own-price effect on supply, S_{ij} is a cross-price effect on supply, D_{ii} is an own-price effect on demand, and D_{ij} is a cross-price effect on demand.*

Condition 4. *Initial effects of eco-labeling increase demand for the green product and decrease demand for the undifferentiated product; and either (a) $|\partial D_e / \partial \rho| = |\partial D_u / \partial \rho|$; or (b) $|\partial D_e / \partial \rho| > |\partial D_u / \partial \rho|$.*

Condition 5. *Development of the environmental certification program creates nonprice incentives that increase green supply relative to conventional supply; and either (a) $|\partial S_g / \partial v| = |\partial S_c / \partial v|$; or (b) $|\partial S_g / \partial v| > |\partial S_c / \partial v|$.*

Referring to the five conditions, we list our main conclusions as the following propositions:

Proposition 1. *Given Condition 1(a), the effect of eco-labeling on the environment is always nonnegative; 1(a) in combination with 2(b) and 4(a) leads to no environmental change; and 1(a) in combination with any other set of conditions generates a positive environmental effect.*

When the alternative land-use is environmentally inferior, any impact that increases total demand for ferns (eco-labeled and unlabeled combined) and improves producer returns generates positive environmental benefits. Even in the case that conventional production

increases as a result of environmental labeling (e.g., given Conditions 2(b) and 4(b)), the net environmental effect is positive. When green fern acreage increases and land is diverted from an environmentally inferior alternative, environmental quality improves.

If the next best alternative land-use is environmentally superior to either type of fern production (i.e., Condition 1(b)), the effect of eco-labeling on the environment may be positive or negative. Any increase in conventional production at the expense of alternative land-uses generates a negative effect on the environment, even as the use of EMPs increases. Propositions 2-4 suggest conditions that could cause the introduction of an eco-label to lead to an increase in conventional production, with negative environmental effects under Condition 1(b).

Proposition 2. Conditions 2(b) and 4(b) together generate an increase in conventional production.

When excess green supply is sold undifferentiated and there is an increase in total farm-gate demand (after accounting for any increase in marketing costs associated with labeling), conventional production rises.

Even if no excess green supply is sold undifferentiated, an increase in conventional production can result from eco-labeling.

Proposition 3. Conditions 2(a) and 3(a) together can lead to an increase in conventional production, if Condition 4(b) occurs with sufficient magnitude.

When a segment of consumers buys the green product with an environmental claim prior to eco-labeling and the eco-label allows access to a large new market, conventional production may rise. This effect occurs if demand-side substitution is significant (consumers readily switch to the unlabeled product as the eco-label price increases) and

supply-side substitution is not (conventional producers do not readily switch to green practices as the green price rises).

Proposition 4. *Conditions 2(a) and 3(b) together can lead to an increase in conventional production, if Condition 5(b) occurs with sufficient magnitude.*

Another possible scenario in which conventional production could increase as a result of eco-labeling occurs when a segment of producers uses green practices prior to development of the certification and labeling program. If the program creates sufficient incentives to encourage a large entry of efficient producers into green production, some growers who used green methods previously may switch to conventional practices. This effect is only possible if Condition 3(b) holds (i.e., as green price falls, producers readily switch to conventional practices, but consumers do not readily substitute the eco-labeled product for the unlabeled product). Although theoretically possible, we consider Proposition 4 very unlikely.

Given Condition 1(b), the effect of eco-labeling on the environment can be positive. The environmental effect is positive, if conventional acreage falls nearly as much as green acreage increases, and if little land is taken out of its environmentally superior alternative use. Propositions 5 and 6 state conditions that are likely to lead to decreases in conventional acreage and positive environmental benefits under Condition 1(b).

Proposition 5. *Given Condition 2(b), either Condition 5(a) or 5(b) leads to a decrease in conventional production.*

When excess green supply is sold undifferentiated (Condition 2(b)), nonprice incentives for producers to switch to green management do not create the unintended effects

(increases in conventional production) generated by increases in green demand. Supply-side incentives unambiguously lead to decreases in conventional production quantities. Especially if the green supply increase associated with nonprice incentives is the result of conventional producers switching to environmental management practices without increasing their acreage significantly, there would be little reduction in the alternative land-use and net environmental benefits would be positive.

Proposition 6. Given Condition 2(a), either Condition 4(a) or 5(a) leads to a decrease in conventional production.

If no excess green supply is sold undifferentiated, eco-labeling generates a decrease in conventional production and positive environmental change as long as the increase in eco-demand is roughly equal to the decrease in unlabeled demand. Likewise, if nonprice incentives cause an increase in green supply roughly equal to the decrease in conventional supply, net environmental benefits are positive. In other words, if an eco-labeling program causes current consumers of the undifferentiated product to switch to the eco-labeled product or conventional producers to switch to environmental management practices, positive environmental effects are likely. Under these conditions, we would expect conventional production to fall and little land to be taken out of its next best alternative use.

Eco-labeling is most effective at generating positive environmental benefits, when alternative land-uses are environmentally inferior, consumers are willing to pay a premium for the eco-labeled product, and producers respond to price and non-price incentives for adopting environmental management practices. Generally, eco-labeling programs are not as effective at producing environmental benefits, when alternative land-

uses are environmentally superior. In this case, substantial reductions in demand for the undifferentiated product and nonprice incentives for conventional producers to adopt certified practices are most likely to generate environmental benefits. When alternative land-uses are environmentally superior, increases in demand for the eco-labeled product without offsetting decreases in demand for the unlabeled product lead to unintended environmental harm.

CHAPTER 5

EFFICACY OF VOLUNTARY ENVIRONMENTAL LABELING AS A POLICY ALTERNATIVE

Voluntary environmental labeling has been proposed as a possible alternative to government-mandated environmental policies. In this chapter, we evaluate the potential efficacy of voluntary environmental labeling as a policy alternative. Within the discipline of economics, policy analysis may include various dimensions by which to evaluate efficacy (Bromley). In our analysis, the following concepts are relevant to policy efficacy: (1) the consequences of a policy (e.g., impact on the environment); (2) Pareto efficiency; (3) cost-effectiveness; and (4) equity (e.g., consideration of who gains and who loses).

A full evaluation of government policy alternatives is beyond the scope of our analysis. Instead we focus on aspects of voluntary environmental labeling that limit its potential to serve as an effective replacement for government-mandated environmental policies.

Literature Review

Although most eco-labels are developed through private or nongovernmental collective initiatives, some authors have suggested that voluntary eco-labeling can serve as an efficient substitute for government-mandated environmental policies. For example, Antle (p.1004) argues that voluntary, information-based programs, such as environmental labeling, are usually more efficient than “collective choice expressed through government policy.” Referring to “green labeling” in particular, he envisions product labeling

policies replacing other types of environmental, food safety, and social policies. He states:

My hypothesis is that this kind of product differentiation could—and eventually will—provide an efficient alternative to the complex set of policies that now exist in the United States to promote conservation and protection of the environment (Antle, p. 1006).

Antle's hypothesis is supported by others in the literature. For example, Nimon and Beghin (p. 802) state that "labels provide a market-oriented instrument to achieve environmental goals, and thereby avoid the inefficiencies associated with mandatory standards, or bans." Hays (p. 16) cites other authors as showing that "eco-labeling can provide the efficient level of a public good." Under restrictive assumptions (e.g., the condition that the public attribute—environmental benefits—coincides with a private attribute—food safety), the analysis of Ibanez and Stenger finds that a food safety label can generate efficient levels of environmental protection.

Despite the appearance of growing support in the academic literature for the efficacy of voluntary environmental labeling, even as a potential replacement for government-mandated environmental policies, we identify several drawbacks to over-reliance on eco-labels. In the remainder of the chapter, we consider the effectiveness at protecting the environment, Pareto efficiency, cost-effectiveness, and equity of voluntary environmental certification and labeling programs.

Environmental Effectiveness

One view of policy analysis contends that an economist's role should be to describe the probable consequences of a policy, in terms of the objectives relevant to policymakers or stakeholders, but to let others decide which policy is best (Bromley; Mishan 1980). Chapter 4 was devoted to identifying the consequences of eco-labeling under different

circumstances. The analysis showed that the aggregate effect of eco-labeling on the environment may be positive or negative, depending on specific market conditions and the relative environmental impacts of alternative land-uses. In this section, we review environmental effectiveness from the perspective of the individual consumer who chooses to purchase an eco-labeled product as a means of affecting environmental change.

Referring to our consumer model introduced in Chapter 2, consider the ability of consumer Type 1, who does not buy any ferns prior to labeling, to reduce the negative environmental impacts associated with conventional fern production. Assume that the Type 1 consumer assigns a high negative value to the environmental impact of conventional ferns, and would purchase ferns if it were not for the environmental impact ($U_X/U_Y > p_u$). Once the eco-label is introduced, the consumer can distinguish (with credibility) between conventionally produced and “green” ferns, and she may start purchasing “green” ferns bearing the eco-label. Consumer 1 is thus expressing her valuation that $-\rho U_B/U_Y$ is greater than the price premium p_r . If $\rho = 1$, she is paying a premium to avoid one incremental unit of B (the public bad) with each purchase of eco-labeled ferns. The comparative static results in (51) and (54) suggest, however, that increasing demand for eco-labeled ferns by one unit does not necessarily reduce conventional production by one unit. In fact, (51) shows that under the first pre-labeling scenario (green production is small relative to conventional), the effect of $\partial D_e / \partial \rho$ on Q_c is ambiguous. Worse yet, under the second pre-labeling scenario, (54) demonstrates that the effect of $\partial D_e / \partial \rho$ on Q_c is unambiguously positive (i.e., conventional production increases). If the next best alternative land use is environmentally superior to either type

of fern production, the environmental impact of this consumer's decision to buy eco-labeled ferns is a negative one. It is quite possible that the consumer who purchases no ferns prior to eco-labeling, but buys eco-labeled ferns after label introduction, is deceived by the "invisible hand" of the market, paying for a one unit reduction in B and receiving instead an increase in B .

Consumer Type 2 purchases conventional ferns prior to eco-labeling. If the new eco-label is sufficiently credible and the consumer's valuation of the environmental attribute is sufficiently high, such that $-\rho U_B/U_Y$ is greater than or equal to the price premium, he will purchase the eco-labeled ferns once the label is introduced. Referring to equations (51) and (54), the net effect of switching consumption from one unit of conventional product to one unit of green product will reduce the quantity of conventional production, under the first pre-labeling condition. Under the second pre-labeling condition, the net effect is zero, and the quantity of conventional production will remain unchanged (assuming no changes in marketing costs). Likewise, the ultimate effect on the environment will be zero. This consumer also may be deceived by the "invisible hand" of the market, paying for a one unit reduction in B , and receiving instead no change in the environment at all.

As described in Chapter 4, supply-side incentives that make green production more attractive to producers are less likely to generate unintended consequences than demand-increasing effects of labeling. Supply-side incentives might include research and extension activities that disseminate information to growers on how to reduce production costs while protecting the environment (or protect the environment without raising costs significantly). Dissemination of information to producers could be part of a

nongovernmental or government-supported certification program. Another supply-side incentive related to voluntary labeling involves risk of liability for environmental damage. Although environmental certification may not be government-mandated, producers often believe that obtaining certification reduces their risk of being held liable for environmental harm (Henriques and Sadorsky; Khanna and Damon; Khanna and Anton; Leppla; and WWF). Supply-side incentives related to eco-labeling programs are partially dependent on government programs and policies (such as state cooperative extension programs and environmental laws).

Government-mandated policy alternatives, such as taxes or subsidies, can be linked to producer adoption of environmental management practices (Griffin and Bromley; Shortle and Dunn). Environmental tax or subsidy schemes linked to production practices create nonprice incentives similar to those for voluntary certification and labeling programs, and can be designed to avoid the unintended consequences resulting from the market interaction effects of an eco-labeling program. Although a subsidy would provide the same incentive structure as a tax for farms that stay in operation under either policy, taxes and subsidies would have different effects on entry and exit behavior (Griffin and Bromley). Whether the policy induces net entry or exit may have important environmental consequences that depend on the environmental impact of the next best alternative use of major inputs, such as land. Ideally, the government could assess the environmental impact of competing land uses and choose between a tax or subsidy accordingly. If the alternative land use is environmentally superior, a tax would be more beneficial. If the alternative land use is environmentally inferior, a subsidy would be preferred. A government-mandated tax or subsidy scheme could be more directly

targeted than a voluntary labeling program, avoid the unintended consequences associated with eco-labeling, and achieve greater environmental effectiveness. The efficacy of voluntary eco-labeling, in terms of protecting the environment, is more limited, especially without the nonprice incentives that are partly dependent on government policies and programs.

Pareto Efficiency

Efficiency refers to achievement of the greatest output relative to inputs or the obtainment of desired objectives at the least expense. Economists often use two specific definitions of efficiency. Productive efficiency implies that “no further reallocation would permit more of one good to be produced without necessarily reducing the output of some other good” (Nicholson, p.502). Pareto efficiency refers to “an allocation of resources” such that it is not possible “to make one person better off without making someone else worse off” (Nicholson, p.502). The Pareto principle involves allocating resources so as to achieve the greatest social welfare, where welfare is defined according to the sum of individual valuations of all the goods and bads available (Mishan 1980).

The concept of Pareto efficiency has been criticized for failing tests of objectivity, consistency, and coherence as a decision-making criterion for policy analysis (Bromley). In particular, an outcome identified as Pareto efficient is unique to the current institutional context and distribution of income and endowments (Bromley). Market prices and compensating variations used to assess costs and benefits depend upon the distribution of income and endowments, definition of property rights, institutions, and every other existing policy (Bromley). Every possible institutional framework has a different Pareto optimum, leaving us with no basis to rank different institutions or policies (Bromley; Mishan 1975). The potential Pareto improvement criterion does not

address society's preferences for different institutional arrangements or policy instruments, ethics, equity, or whether some people are made worse off (Bromley; Mishan 1975 and 1980). Despite these shortcomings, the economics profession continues to rely heavily on the concept of Pareto efficiency to assess costs, benefits, and social welfare (Bromley; Mishan 1975 and 1980). Acknowledging its limitations, we find that the Pareto criterion still provides some useful insights in our evaluation of the efficacy of voluntary environmental labeling.

Under perfect competition (with perfect information and no externalities), individuals acting independently in a market economy achieve production and Pareto efficiency by equating the marginal rate of transformation (referring to the trade-off in production of two goods) to the marginal rate of substitution (referring to the trade-off in a consumer's preferences over two goods). Both of these ratios are linked by the market equilibrating price ratio.

When markets are not perfectly competitive, market failure occurs, and market outcomes are inefficient from a Pareto perspective. Although susceptible to inefficiencies as well, government intervention in a market economy is justified to help correct for market failures and move resource allocations closer to an socially desirable (efficient and equitable) outcome.

Two sources of market failure are relevant to the analysis of environmental labeling. The first source is imperfect information. The second source stems from the existence of externalities and public goods. The problem of imperfect (asymmetric) information is discussed in Chapter 2. To reiterate, when consumers do not have perfect information about the characteristics and quality of products on the market, they will

have difficulty identifying their most efficient, or welfare maximizing, consumption choices. Likewise, if producers cannot credibly signal information about product characteristics and quality to consumers, consumers will be unwilling to pay higher prices for uncertain quality, and there will be no incentive for producers to provide those product characteristics. Imperfect information can reduce the provision of quality to a suboptimal or inefficient level.

Another major source of market failure arises when individual production and consumption decisions are not entirely independent (i.e., when externalities or public goods exist). An externality refers to a cost or benefit that is incurred by someone other than the people or firms engaging in a market transaction or activity. When compensation for the “external” costs or benefits is not required, there is generally no reason for individuals engaging in the transaction or activity to consider the “external” impacts. Because these impacts are external to the decisions of those engaging in the transaction or activity, they are called externalities. Externalities may be positive (benefits) or negative (costs). Pollution is a negative externality when it impacts others besides those generating the pollution, and the polluters are not required to compensate those affected.

A public good refers to a good that is nonrival and nonexcludable or entails high exclusion costs. In other words, when one individual contributes to providing a public good, a positive externality benefits others as well. Noncontributors cannot be easily excluded from enjoying the benefits of a public good, and one person’s enjoyment of a public good does not diminish the enjoyment of others. Environmental quality, such as clean air or water, is typically a public good. When environmental quality is provided or

protected, many people benefit simultaneously. A public bad is associated with negative externalities, and refers to reduction in a public good (e.g., environmental degradation).

With these concepts in mind, we start by considering the informational aspects of environmental labeling. Environmental certification and labeling programs can reduce market inefficiencies owing to asymmetric information inherent to credence attributes. As detailed in Chapter 2, credence attributes, such as those associated with the environmental impact of a good's production, are not easily verified by consumers. The resulting asymmetric information, as described by Akerlof, can lead to market failure and reduce incentives for producers to protect the environment.

Credible, third-party certification and labeling programs can help overcome the asymmetric information problem and improve efficiency regarding market provision of environmental attributes. According to Teisl and Roe (p.141):

This removal of information asymmetry or subsidization of search costs is clearly beneficial to consumers as they are now more informed as to the exact attributes of the product. Choices will be more closely in line with preferences, and uncertainty regarding the nature of product attributes is minimized during the choice process. Firms that produce goods with desirable attributes also gain, as they are rewarded for marginal improvements in the quality of various attributes.

Various factors, however, may limit the ability of eco-labels to overcome information-based inefficiency surrounding the environmental impacts of production. Voluntary eco-labels do not inform consumers directly about the negative attributes of alternative products. Also, most consumers are unaware of the environmental impacts associated with agricultural production (van Ravenswaay and Blend). Furthermore, the amount of information required to capture all the environmental and social implications of every product a consumer buys would be enormous. This is problematic because products have limited label space, and consumers have a limited capacity to process product

information. Teisl and Roe (1998, p.142) describe consumers as “boundedly rational,” in that purchasing decisions are made under significant “time and cognitive constraints.” They cite studies showing that consumers frequently fail to identify the best deal when price structures are complicated (e.g., for phone service) or even when product size alone varies. Although government can play a role in improving information provision and reducing consumer confusion (e.g., by standardizing formats), the amount and complexity of information that can be transmitted effectively via an eco-label will always be rather limited.

Even if voluntary environmental labeling helps overcome information-related market failure, it may not overcome the other major source of market failure stemming from externalities and public goods. As Samuelson (1954, 1955) demonstrated, the Pareto optimality condition for provision of public goods differs from that of private goods. As a result, public goods are typically underprovided by the free market. If consumers do not fully account for the aggregate (public) costs and benefits of their individual actions, a market system without appropriate institutions will result in depletion of common resources and inefficient levels of public goods, such as environmental quality.

When one person pays for a unit of public good provision, he bears the entire cost but receives only a small fraction of the total benefits that accrue to many individuals who enjoy the public good. Also, the marginal effect of one individual’s consumption choice on a large-scale public good is negligible. For example, when one individual switches from purchasing unlabeled ferns to eco-labeled ferns, it is not likely that she perceives a noticeable improvement in water quality in the St. John’s river as a result.

According to Sunding (p.722), “individuals would not freely consume a product produced by an alternative method due to the free-rider problem because they perceive that their consumption choices have no effect on the level of provision of the public good.” Sunding (p.723) goes on to state that “an unregulated market with differentiated products (even with perfect information and no moral hazard problems involving fraud) may not reach an efficient outcome due to free riding.”

There is a lack of evidence that environmental labeling can help overcome the inefficiencies relating to this second source of market failure. If voluntary environmental labeling cannot overcome the market failure associated with externalities and public goods, then to argue that labeling is an efficient replacement for government policy is to argue that there is no role for government in providing public goods and accounting for externalities.

Pareto efficiency is assessed using a basic model of the type described by Samuelson (1954; 1955) and Sandmo (1973). Consider the simplest model of two consumers with homogeneous preferences defined over three characteristics Y , X , and B , as in the consumer model presented in Chapter 2. The homogeneous preference assumption is not a restrictive one, since the same results are obtained for heterogeneous consumers. Recall that B is a public “bad”, representing contamination of water resources, with a negative marginal utility. Each consumer is affected by the aggregate level of B , not just by the individual contribution to B . Market goods y , q_c , and q_g , supply the three characteristics, as in the consumer model of Chapter 2. Conventional production, q_c , contributes to the public bad, B , at a one-to-one ratio, but green production, q_g , does not contribute to the public bad.

We compare three cases. The first case is a market solution without an eco-label and zero producer credibility (imperfect information). Consumers cannot distinguish q_c from q_g and do not trust a producer's environmental claims. The second case is a market solution with an eco-label and complete credibility (perfect information), so that consumers place full trust in the environmental claim. In the market solutions, each consumer maximizes his individual utility, but does not account for the utility of the other. The third case is the Pareto-optimal solution that maximizes aggregate welfare. We assume that social welfare is simply the sum of the individual utilities: $W = U^i + U^j$. The economy's production possibilities frontier is defined by the transformation function: $F(Y, Q_c, Q_g) = 0$. This function is assumed to possess the standard properties with diminishing marginal returns, such that the marginal rate of transformation, F_g/F_c , increases as the production ratio, Q_g/Q_c , increases. It is assumed that the marginal rate of transformation equals the price ratio, and that a positive quantity of each good is always produced.

In the first case, with $\rho = 0$, consumers cannot distinguish between q_c and q_g . If positive quantities of both are purchased, consumers i and j equate their individual marginal rate of substitution to the price ratio (or marginal rate of transformation), and the market solution is

$$(5-1) \quad \frac{U_X^i + U_B^i}{U_X^i + U_B^i} = \frac{U_X^j + U_B^j}{U_X^j + U_B^j} = \frac{F_g}{F_c}$$

The first-order condition expressed in Eq. 5-1 implies that $F_g/F_c = 1$, if consumers cannot distinguish between q_g and q_c .

In the second case, $\rho = 1$, the green product is eco-labeled and consumers have full information (recognizing that q_g does not contribute to the public bad, B). The first-order condition representing the market solution in this case is

$$(5-2) \quad \frac{U_X^i}{U_X^i + U_B^i} = \frac{U_X^j}{U_X^j + U_B^j} = \frac{F_g}{F_c}$$

This solution, with $U_B < 0$, implies that $F_g/F_c > 1$.

In the third case, social welfare is maximized by considering the full effect of each individual's consumption decision on the utility of both. The solution provides the Pareto-efficient outcome. The first-order conditions for the maximum welfare solution are

$$(5-3) \quad \frac{U_X^i}{U_X^i + U_B^i + U_B^j} = \frac{U_X^j}{U_X^j + U_B^j + U_B^i} = \frac{F_g}{F_c}$$

Comparing Eq. 5-3 with Eq. 5-2 and recognizing that $U_B < 0$, one sees that F_g/F_c in the welfare maximizing solution must be strictly greater than F_g/F_c in the market solution with full information (perfectly credible environmental labeling). These three conditions imply that the economy's production ratio, Q_g/Q_c , is smallest in the market solution without the eco-label, higher in the market solution with the eco-label, and highest in the welfare maximizing solution. The eco-label outcome is an intermediate solution, but clearly inferior to the Pareto efficient solution. The results of this exercise support the assertion that environmental labeling helps reduce market failure resulting from imperfect information, but does not reduce the market failure associated with externalities and public goods. Even when the population of consumers is identical to the population affected by the negative impacts of production and unintended consequences are avoided,

it is unlikely that a Pareto efficient level of a public attribute embodied in an eco-label will be provided by a voluntary labeling program.

When the population affected by the negative impacts of production does not match the population of consumers of the good produced, the potential for voluntary labeling to provide an efficient replacement for government policy is weakened further. In our modern economy, heavily reliant on interregional and international trade, environmental labeling programs are vulnerable to spillover effects, which occur when the population of consumers does not match the population affected by the negative externalities from production (e.g., the residents in the producing region). If conventional production generates a negative externality in the producing region, environmental labeling provides a direct means only for consumers of the conventional product to affect changes in production through a shift in their purchasing decisions. Typically only a small fraction of those affected by a production externality are in the market as consumers of the product, and only a very small portion of the consumers of a product live in the producing region. As long as some consumers continue to buy uncertified products, negative externalities will continue to be imposed on others.

Consider the case of heterogeneous consumers living in the fern-producing region with water quality issues. Here we reproduce Eqs. 2-22 and 2-23 as

$$(5-4) \quad \frac{U_X}{U_Y} + \frac{U_B}{U_Y} \leq p_u$$

$$(5-5) \quad \frac{U_X}{U_Y} + (1 - \rho) \frac{U_B}{U_Y} \leq p_e.$$

Equations 5-4 and 5-5 represent the Kuhn-Tucker conditions for the utility maximizing consumer. If $\rho = 1$, the eco-label is perfectly credible, and a consumer purchases the eco-

labeled product if $U_X/U_Y > p_e$. Regardless of how high a consumer's valuation of water quality ($-U_B/U_Y$) is, she will not purchase the eco-labeled product if $U_X/U_Y < p_e$. For this consumer, a voluntary environmental labeling program for ferns provides no vehicle for her to express her preferences for water quality.

Furthermore, a positive eco-label on "greener" products is not directly targeted at the source of the externality. Paying a premium for an eco-labeled product is a very indirect way to attempt to correct for a negative externality associated with the production of a different product. Even if conditions are such that unintended consequences are avoided and environmental quality improves, it is doubtful that voluntary labeling will generate an efficient level of environmental protection in the Pareto sense.

Of course it is possible that a government-mandated policy alternative could be even less efficient from a Pareto perspective. In our analysis, we focus on the inadequacy of relying on voluntary environmental labeling as a policy alternative, but do not attempt a full comparison of different policy choices.

Cost-Effectiveness

An alternative efficiency criterion is that of cost-effectiveness. Cost-effectiveness analysis attempts to answer the following question. Given a collective objective, determined through some political process, how can the objective be achieved at the least cost? A certain policy, program, or project is cost-effective, if it achieves the desired objective at least cost relative to available alternatives.

We use cost-effectiveness analysis to compare policy alternatives in a theoretical case involving nonpoint externalities, such as groundwater contamination from fern production. We assume that political consensus has identified pollution reduction as a

desired objective. Although a voluntary environmental labeling program alone would be unlikely to achieve a substantial amount of pollution reduction in most cases, in this section we assume it could obtain the same level of pollution abatement as under a government-mandated environmental policy. The relevant question, then, concerns cost effectiveness. How can a pollution reduction target be achieved at least cost to society? First, we evaluate the costs of a voluntary, certification and labeling program based on environmental management criteria. Then we draw comparisons to a government-mandated environmental management incentive program.

Environmental certification and labeling programs require the following costly activities: (1) development of an appropriate standard for environmental management practices (EMPs) and identification of criteria on which farms, processors, and handlers will be judged; (2) a certification process and related oversight activities, typically administered by an independent, non-governmental certifying agency; (3) grower compliance costs; and (4) product labeling, market segregation, identity preservation, and chain-of-custody measures.

Development of an environmental standard for farm management practices usually involves collection of information, deliberation by a committee, collaboration with scientists, producers, consumers, or other interested parties, and public feedback. This process may take several years, requiring considerable time and expenses.

The actual certification process typically includes review of paperwork and records, as well as periodic on-site inspections and monitoring. Administrative and overhead costs incurred by the certifying agency must be considered as well. Certifying agencies generally charge a certification fee that varies with the size and income of the certified

entity (farm, processor, or handler). A 1999 study of eleven certifying agencies collected information on fees charged for organic certification. “First year certification costs averaged \$579, \$1,414, \$3,623, and \$33,276 for farms with incomes of \$30,000, \$200,000, \$800,000, and \$10,000,000, respectively” (Ferguson 2004, p.2).

In order to obtain certification, a grower typically incurs costs associated with adopting environmental management practices. These might include investment in new facilities or equipment, additional material or application costs, and additional expenses for management, recordkeeping, and paperwork.

Once a farm is certified, it is entitled to sell its products bearing an eco-label. Marketing costs are typically higher for eco-labeled products. In the case of the organic standard, processors and handlers of organic products throughout the marketing channel must be certified. The certified product must be segregated from uncertified product during storage, processing, transport, and distribution. Market outlets for eco-labeled products tend to be smaller and fewer than conventional, often increasing per-unit marketing costs due to lack of economies of scale.

Using the example of an environmental management practice (EMP) certification and labeling program being developed for the ornamental plant nursery industry, and leatherleaf ferns in particular, we assume that significant numbers of fern consumers are willing to pay a price premium for eco-labeled ferns in order to achieve a certain amount of pollution abatement. In addition, we assume that significant numbers of plant nurseries adopt EMPs in response to the price incentive. In this simplified model, it is also assumed that the amount of pollution abatement corresponds directly to the number of farms that change their management practices in order to obtain certification.

Let N denote the number of farms in a producing region, each facing a discrete choice between adopting best management practices or not. To simplify the analysis, it is assumed that each farm produces the same quantity of output, q , and incurs the same total cost, $C_c(q)$, for production and marketing of the conventional product (excluding costs associated with environmental compliance, certification, and labeling). Farms are heterogeneous only with respect to their costs of complying with the EMP standard. Farms can be ordered according to their individual compliance costs (i.e., the additional costs they would incur to comply with the environmental standard). Using notation consistent with the producer model presented in Chapter 3, a marginal compliance cost function, $C_g^m(X_g)$, relates the cost of compliance for the marginal farm, C_g^m , to the number of farms adopting environmental management practices, X_g . The marginal compliance cost, C_g^m , is a positive function of X_g , and the compliance cost for an individual, intramarginal farm, C_g^i , ranges from zero to C_g^m (i.e., $0 < C_g^i < C_g^m$). Also, participating farms must pay a certification fee, C_i , to the certifying agency. This fee is the same for all participating farms. Eco-labeling requires additional processing, handling, and marketing costs associated with identify preservation throughout the marketing channel. These costs are represented by the per-unit value, c_e , which is the same for all participating farms. Figure 5-1 shows the relationship between all costs additional to conventional costs and the number of participating growers.

Under a voluntary labeling program, the farm's profit function is:

$$(5-6) \quad \Pi = p_u q - C_c(q) - (C_g^i + C_i)D + [(p_r - c_e)q]D$$

where p_u is base price (for the unlabeled product), p_r is the price premium obtained for the eco-label, and D is a discrete choice, binary variable (taking a value of "1" if the farm

participates, and “0” if not). A farm chooses to participate in all three steps—compliance, certification, and labeling—or chooses not to participate at all. In the latter case, the farm continues conventional production and marketing. The farm is indifferent between participating in the voluntary program or not when:

$$(5-7) \quad (p_r - c_e)q = C_g^i + C_i$$

The additional revenue obtained from eco-labeling just equals the additional costs of compliance and certification for the marginal farm.

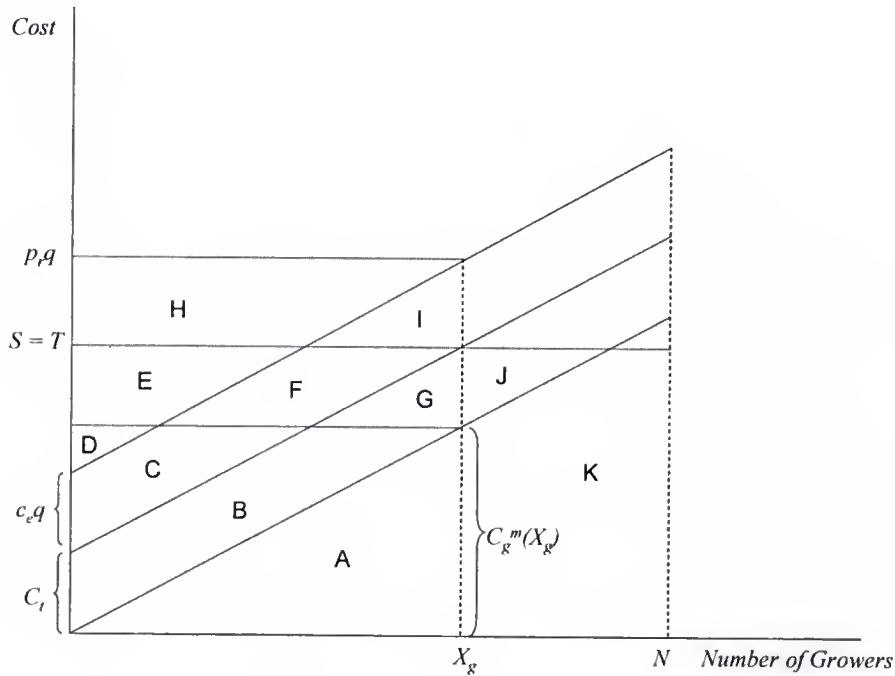


Figure 5-1 Cost comparison of labeling vs. subsidy or tax policy

The total producer cost of participation in the labeling program is:

$$(5-8) \quad \int_0^{X_g} C_g^m(X_g) dX_g + C_i X_g + c_e q X_g$$

Consumers, however, pay a total cost of $p_r q X_g = (C_g^m + C_i + c_e q) X_g$ (A + B + ... + I in Figure 5-1), which exceeds the total producer cost of participation (A + E + ... + I in

Figure 5-1). Participating growers with compliance costs below that of the marginal (indifferent) grower keep the difference ($B + C + D$ in Figure 5-1) as producer surplus.

It remains to compare these costs with the costs of achieving the same level of pollution reduction through a government-mandated policy. Considering the wide variation in actual costs of government policies, we avoid making definitive generalizations about the cost-effectiveness of voluntary labeling vs. government-mandated policies. Instead we draw the comparison to highlight costs associated with the voluntary labeling program, that are not required under the government-mandated policy.

One type of environmental policy, described by Griffin and Bromley, and Shortle and Dunn, involves a tax or subsidy linked to specific management practices, inputs, outputs, or other factors affecting the level of non-point pollution generated by a particular farm. Griffin and Bromley (p. 550) identify various policy costs, including political decision-making, costs of policy formulation and design, administrative costs, enforcement costs, and “periodic policy reevaluation” costs. Government-mandated tax or subsidy programs, used to reduce non-point pollution in agriculture, are similar in many ways to environmental labeling programs. For example, the government could develop an identical EMP standard through a similar process to that used by nongovernmental organizations. Furthermore, the government could rely on the same certifying agency to oversee the certification process as in the nongovernmental case. Thus, costs of developing the standard, certification costs, oversight and monitoring, and grower compliance costs should be similar under the hypothetical government tax or subsidy policy and the voluntary labeling program. We assume that under the government program, a tax or subsidy is set at a level that achieves the same amount of

grower participation (and hence the same environmental improvement) as under the voluntary labeling program.

The profit function for each farm under the government tax or subsidy program is

$$(5-9) \quad \Pi = p_u q - C_c(q) - (C_g^i + C_t)D + SD - T(1 - D)$$

where p_u is the undifferentiated output price, S is a lump-sum subsidy provided by the government, T is a lump-sum tax levied by the government, and D is a discrete choice, binary variable (taking a value of “1” if the farm participates, and “0” if not). Under the subsidy policy, $S > 0$ and $T = 0$. Under the tax policy, $T > 0$ and $S = 0$.

For the marginal firm, indifferent between participating in the subsidy program or not

$$(5-10) \quad S = C_g^m + C_t$$

The sum of the compliance cost and certification fee just equals the subsidy amount for the marginal farm. If the government instead levied a lump-sum tax, T , on nonparticipating farms, the marginal farm would be indifferent when:

$$(5-11) \quad T = C_g^m + C_t$$

The sum of the compliance cost and certification fee just equals the tax amount for the marginal farm.

The total producer cost of participation in the government subsidy program is:

$$(5-12) \quad \int_0^{X_g} C_g^m(X_g) dX_g + C_t X_g$$

This producer cost corresponds to A + E + F + G in Figure 5-1. The government, however, pays a total cost of $SX_g = (C_g^m + C_t)X_g$ (A + B + ... + G in Figure 5-1), which exceeds the producer cost. Growers with compliance costs below that of the marginal

(indifferent) grower keep the difference as producer surplus ($B + C + D$ in Figure 5-1), identical to the voluntary labeling program.

Under the tax policy, total cost incurred by nonparticipating growers is $T(N - X_g) = (C_g^m + C_v)(N - X_g)$, which corresponds to $J + K$ in Figure 5-1. Participating growers incur the same cost as under the subsidy program (but do not receive the subsidy).

A comparison of the total cost of the tax policy vs. the labeling program is inconclusive, since the total tax cost depends on N but the labeling program does not. The total cost of the subsidy program, however, is clearly lower than the cost of the voluntary labeling program in this hypothetical example. The labeling program cost exceeds the subsidy program cost by $c_e q X_g$ ($H + I$ in Figure 5-1). The additional marketing costs required for the voluntary labeling program are not necessary for the government subsidy program. The government program could achieve the same level of pollution abatement, while avoiding the marketing costs associated with labeling.

Certainly we have overlooked some costs involved in all three alternatives discussed. Therefore, we do not make a conclusive generalization about the cost-effectiveness of voluntary labeling programs relative to government-mandated policies. Our analysis emphasizes, however, that additional costs, necessary for identity preservation and marketing in the labeling program, are not needed under the government subsidy policy. Also, government subsidy or tax policies, linked to environmental management practices, are more directly targeted than the incentives generated by consumer purchases of labeled products, and can be designed to avoid the unintended consequences that may be associated with voluntary environmental labeling. These

factors diminish the cost-effectiveness of environmental labeling relative to tax or subsidy policies.

Equity

Public policies affect the distribution of opportunities and economic advantage among individuals (Bromley). The distribution of costs and benefits and perceived fairness of a particular policy are major concerns among stakeholders. A full policy assessment should consider equity or the distribution of gains and losses.

Continuing the analysis from the previous section, we compare the distributional effects of the voluntary labeling program and government tax or subsidy policies. In the labeling program, consumers pay a total of $p_g X_g = (C_g + C_t + c_e q) X_g$. Of this amount, efficient green producers (those with compliance costs less than the marginal, indifferent producer) receive the amount corresponding to B + C + D in Figure 5-1 as surplus. The remainder goes to factors of green production, certification, and marketing (A + E + F + G + H + I in Figure 5-1). Government does not collect or disperse any funds, although it might be involved with prosecution of fraudulent claims or resolution of disputes.

In the government subsidy program, taxpayers pay $SX_g = (C_g^m + C_t) X_g$. Of this amount, efficient green producers receive the same surplus of B + C + D in Figure 5-1. The remainder goes to factors of green production and certification (A + E + F + G in Figure 5-1).

In the government tax program, nonparticipating producers pay $T(N - X_g) = (C_g^m + C_t)(N - X_g)$, and participating producers pay the amount of Eq. 5-12. The government receives $T(N - X_g)$, which corresponds to J + K in Figure 5-1, and the amount of Eq. 5-12 (A + E + F + G in Figure 5-12) goes to factors of green production and certification. We do not consider how the government spends the tax receipts, $T(N - X_g)$.

Under the assumption that the number of participating growers and environmental improvement is the same under all three policy alternatives, the analysis provides insight regarding the distribution of policy impacts. Participating growers receive the same surplus ($B + C + D$) under both the voluntary labeling and subsidy policies. Under the tax policy, however, participating growers must pay for the cost of compliance and certification ($A + E + F + G$), and they forgo the producer surplus obtained under the other two policies. Nonparticipating growers would be unaffected by either the labeling or subsidy policy (assuming their output price remains unchanged), but would be required to pay the total tax amount ($J + K$) under the tax policy.

The distribution of producer costs and benefits suggest that producers would support either a voluntary labeling program or government subsidy policy. Both participating growers (with positive compliance costs) and nonparticipating growers (bearing the tax burden) would oppose the government tax policy.

The preference of consumers depends in part on the perceived change in their tax burden (under the tax or subsidy policy) vs. the amount they would pay in eco-label premiums (under the voluntary labeling program). Consumers pay $p_u q X_g$ under the labeling program, whereas taxpayers pay $S X_g$ under the subsidy policy. Even when the former amount exceeds the latter (as in our example), an individual perceiving a large impact on his tax burden relative to the amount he pays in eco-label premiums would tend to prefer the voluntary labeling program. Consumers and taxpayers (excluding fern growers) receive the benefits of environmental protection without having to incur the costs under the tax policy (assuming p_u is unaffected).

Individuals express preferences not only over commodities and public goods (or bads), but also over institutional arrangements. Institutional preferences might include preferences for collective action vs. individual action or government regulation vs. other incentive structures. Some individuals may consider it unfair if polluters have the initial right to pollute, and may protest the idea that consumers or citizen groups must pay to protect or cleanup the environment. Other individuals might object most strongly to government regulation of industry or the assumption that society has the initial right to a clean environment. For example, Sunding reports results of a consumer survey asking respondents their willingness to pay for food labeled pesticide-free and their attitude toward a ban on pesticide-use in agriculture. Interestingly, 7% of respondents stated zero willingness to pay a premium for pesticide-free food, but supported regulation requiring that food be grown without pesticides (Sunding). Another 15% of respondents were willing to pay a premium of 25% or more for pesticide-free food, but opposed a regulatory ban on pesticides in agriculture (Sunding). These results provide evidence that some individuals favor regulation over voluntary labeling schemes and vice versa. Their preferences probably have more to do with equity than with any notion of economic efficiency.

Voluntary environmental labeling is based on the premise that producers have a right to pollute, and that willing consumers must pay extra to protect the environment. This has implications both for equity and efficiency. The divergence between maximum willingness to pay for a good and minimum willingness to accept to relinquish a good has been documented in numerous studies (Horowitz and McConnell). This divergence implies that the initial distribution of property rights affects the efficient outcome even

with zero transaction costs, violating the Coase (1960) theorem. If society agrees that the public has the initial right to a clean environment and there is consensus on positive benefits associated with environmental protection, then voluntary environmental labeling is both inequitable and inefficient as a replacement for mandatory environmental policies.

Conclusions on Efficacy

In this chapter, we evaluated the efficacy of voluntary environmental labeling in terms of environmental effectiveness, Pareto efficiency, cost-effectiveness, and equity. The main conclusions of our analysis are summarized here.

Drawing on our analysis from Chapter 4, we identified circumstances that render eco-labels ineffective at protecting the environment. In particular, when alternative land-uses are superior to either type of production, the effects of eco-labeling are likely to result in worse environmental degradation in the producing region. Eco-labeling may be ineffective at improving the environment, even when alternative land-uses are environmentally inferior. For example, when excess green supply is sold on the undifferentiated market, the effect of consumers switching from unlabeled consumption to eco-labeled consumption (in equal proportion) results in no change in production or environmental impacts. Even when a large segment of consumers is willing to pay premiums for eco-labeled products and a large segment of producers is willing to supply eco-labeled products at a reasonable price, voluntary environmental labeling may be ineffective at protecting the environment and could lead to further environmental degradation. Nonprice incentives for producers to adopt green practices are less likely to lead to further environmental degradation than the incentives created by large increases in demand. Although nonprice incentives may be important aspects of a voluntary eco-label program, they often depend on environmental laws and government support for

dissemination of information to producers. Under reasonably common circumstances, voluntary environmental labels are not likely to be effective at facilitating positive environmental change, especially as a replacement for government environmental programs and policies.

Even if unintended consequences do not occur, we find reason to believe that a policy of voluntary environmental labeling would not provide a Pareto efficient level of environmental protection. Eco-labels are limited in their ability to overcome incomplete information associated with production impacts and do not reduce market failures associated with externalities and public goods. Also, the population affected by negative production externalities associated with a particular good does not typically coincide with the consumer market for that good, further limiting the ability of voluntary labeling to capture all relevant social values. Our analysis highlights factors that reduce the efficacy of eco-labels from the perspective of Pareto efficiency.

A model is presented that compares the costs associated with achieving a certain level of environmental improvement under a voluntary labeling program, environmental tax, and subsidy policy. Government-mandated tax or subsidy policies based on EMP certification do not require the additional handling and marketing costs associated with labeling and avoid the potentially perverse environmental effects that can occur as a result of consumer-driven incentives. Our analysis identifies factors that diminish the cost-effectiveness of voluntary labeling relative to tax or subsidy policies.

The distribution of impacts among stakeholders provides insight regarding the perceived equity and policy preference of interest groups. Producers reap the greatest benefits from voluntary labeling and subsidy policies, but bear the costs of an

environmental tax policy. It is not surprising that the former alternatives tend to be most favored by producer groups. Consumers willing to pay an eco-label premium bear the costs of voluntary labeling, and taxpayers provide the funds for a subsidy policy. Direct government oversight is required for the tax and subsidy policy, but not for the voluntary labeling program. Support for, or opposition to, the policy alternatives may depend on perceptions of tax burden relative to premium payments or preferences for institutional arrangements, such as government programs vs. voluntary, market-based choices.

Voluntary environmental labeling has appeal in that it avoids command-and-control environmental regulation, subject to its own set of inefficiencies and inequities. Our analysis does not fully address the efficacy of various mandatory environmental policies. Instead we focus on the effectiveness, efficiency, and equity of voluntary labeling.

When reasonable political consensus is not achieved regarding the costs or benefits of environmental measures, voluntary labeling can be used as a flexible means of accounting for heterogeneous preferences and the values of small segments of consumers. Certain market conditions, however, diminish eco-labeling effectiveness at protecting the environment and can lead to increased environmental degradation. The public nature of environmental protection, information limitations, and incongruence between consumer markets and the individuals bearing external costs from production of a particular good, limit the ability of voluntary eco-label markets to account for social values and lead to Pareto efficient outcomes. Costs associated with identify preservation and marketing of eco-labeled products reduce the cost-effective relative to government-mandated environmental taxes or subsidies. Voluntary eco-labeling places the burden of environmental protection on those consumers willing to pay premiums. In terms of

effectiveness, efficiency, and equity, voluntary environmental labeling has considerable shortcomings as a replacement for government environmental policies.

CHAPTER 6 FLORIDA'S ORGANIC CITRUS SECTOR: RESULTS OF A 2003-04 STUDY

In this chapter, we present results of research on the organic citrus sector in Florida. Our study provides basic data on the sector and insight regarding production and marketing of an important eco-labeled commodity.

Introduction

Florida accounted for 74% of U.S. domestic production of citrus in the 2002-03 season with 718,100 acres bearing citrus fruit (FASS). The total on-tree value of Florida citrus production in 2002-03 was \$815.9 million. This figure is the lowest since 1985-86 (FASS). Declining acreage and production in recent years reflect worsening economic conditions for growers as U.S. per capita citrus consumption (especially of orange juice) declines, international competition increases, and on-tree citrus prices fall (FASS).

In contrast, organic agriculture has experienced rapid growth in recent years. Increasing at rates of about 20% annually since 1990 (Dimitri & Greene), organic retail sales were estimated at more than \$9 billion in the U.S. and about \$21 billion in all major world markets in 2001 (Greene & Kremen). Organic production in the U.S. has expanded to meet this growing demand. U.S. organic fruit and vegetable acreage rose by more than 30% between 1997 and 2001, while organic pasture and rangeland doubled (Greene & Kremen; Dimitri & Greene). Organic agriculture, though still small as a portion of total agricultural production, is a growing phenomenon that provides an attractive alternative for some growers.

Consistent with this trend, an organic citrus sector has emerged in Florida. A 1993 survey identified 16 organic citrus growers covering 568 acres, and collected information on grower characteristics, production practices, problems, and costs (Swisher, Monaghan and Ferguson; Swisher and Monaghan). Considerable growth has occurred in the Florida organic citrus sector since 1993.

Despite the rapid growth of organic agriculture, information on organics in general, and organic citrus in particular, is scarce. We identified several research needs through a review of existing literature and meetings with organic citrus growers, researchers and extension personnel held in 2001 and 2002. According to the Third Biennial National Organic Farmers' Survey, a lack of information on organic production and markets, and the high cost of organic inputs, are major impediments for organic agriculture (Walz). The Scientific Congress on Organic Agricultural Research (SCOAR 2003a and 2003b) concluded that economic research on production practices, markets, and profitability of farming systems were important research needs. Similarly, at meetings held in Florida, organic citrus growers asserted that data on existing organic production and markets were a top priority, among various research needs.

We formulated a research proposal to address these research needs. The Organic Farming Research Foundation awarded a grant to support our research.

Research Objectives

The primary objective of our research on the organic citrus sector was to address some of the most pressing research needs identified above. Our main purpose was to collect, analyze, and disseminate information that would benefit organic citrus growers and others in the organic citrus industry, agricultural researchers, extension agents, and policymakers.

A secondary objective was to connect the empirical research to issues identified in the theoretical analysis of previous chapters. In particular, relevant issues pertain to producer incentives and disincentives for adopting organic practices, producer characteristics that may influence the adoption decision, and alternative land-uses.

We identified several specific research questions. What are the current acreage, production volumes and primary market channels for organic citrus in Florida? What characteristics distinguish organic citrus growers and their farm enterprises? How is organic citrus grown? What are the main inputs used, and what are the production costs? How do various factors affect the profitability or economic viability of organic citrus production? What are the main incentives and disincentives for, and alternatives to, organic citrus production? What sources of information do organic citrus growers rely on, and what are their primary research needs?

Research objectives included

1. Identify existing acreage, production volumes, and market channels for organic citrus
2. Characterize organic citrus growers and their farm enterprises
3. Obtain a description of typical grove care practices, estimate costs of organic citrus production, and create representative production budgets
4. Identify the primary incentives and disincentives for, and alternatives to, organic citrus production
5. Document the main sources of information on which organic growers rely and their primary research needs.

In meeting these five objectives, we expect to increase our understanding of the organic citrus sector, and our ability to anticipate and track market responses to changing circumstances, to assist growers with budgeting and farm planning, and to guide further research that would be relevant to growers.

Research Method

The research method is a census of currently certified organic citrus growers and handlers and a convenience sample of exiting and transitional growers. Exiting growers are previously certified organic citrus growers who gave up their certification within the last two years. Transitional growers have applied for organic certification, but are not yet fully certified. Data is collected through a combination of in-person and telephone interviews structured by a pre-tested questionnaire designed to accomplish the research objectives.

All fifty U.S. certifying agents accredited by the USDA were contacted between May 2003 and March 2004 for their public list of certified entities or to verify that they did not certify any organic citrus entities in Florida. Also, a list of organic growers registered with the Florida Department of Agriculture and Consumer Services (FDACS) was obtained (via personal communication). This list, compiled for the first time in the 2003-04 season, contains all registered organic growers shipping during the 2003-2004 season. Final verification of the FDACS list and statistics was made on March 25, 2004.

Thirty-nine organic citrus growers who were certified sometime between the 2001-02 and 2003-04 seasons or have initiated the transition to organic and will be fully certified by the 2004-05 season were identified through these sources. Interviews were conducted with 32 of the 39 growers (14 in-person interviews and 18 telephone interviews) between July 2003 and March 2004. Four growers declined to be interviewed, and the remaining three could not be contacted.

Of the 39 organic citrus growers identified, 31 were current (fully certified in the 2003-04 season), 6 were exiting (previously certified during the 2001-02 or 2002-03 seasons, but no longer certified), and two were transitional (will not be fully certified

until the 2004-05 season). The 31 current organic growers represent a census of the entire population of certified organic citrus growers in Florida as of the 2003-04 season.² The exiting and transitional growers contacted in this study represent a convenience sample, since the authors do not believe that they identified the entire population of exiting and transitional growers.

At least two of the certified growers manage groves for additional grove owners (who were not contacted), either in a cooperative or other management arrangement. For the purposes of this report, a “grower” refers to one certified entity with organic citrus producing land. A certified entity that owns or leases groves and manages for other landowners (who themselves are not certified individually) counts as one grower only.

In addition, 16 organic packers, processors, or intermediate handlers were identified through lists provided by USDA-accredited certifying agents as being active in the 2003-04 season. Fourteen of these were interviewed (12 telephone interviews and 2 in-person interviews).

Acreage, Production, and Markets

Acreage

Information on acreage was obtained for all thirty-nine growers identified by our study. For those growers who could not be contacted, acreage figures were obtained from their certifying agent or FDACS.

Certified organic acreage has increased considerably since the 1993 survey that documented 568 acres. The USDA provides estimates for organic citrus acreage in Florida for 1997, 2000, and 2001, increasing from 2,296 to 6,056 acres. As of August

² One ten-acre experimental organic citrus grove owned by the University of Florida is not included.

2003, organic citrus growers placing fruit into commercial channels are required to register with the Division of Fruit & Vegetables, License and Bond according to Chapter 20-39.017 of the official rules affecting the Florida Citrus Industry (pursuant to Chapter 601, Florida Statutes). Thus, for the first time in the 2003-04 season, organic citrus growers are required to register with the Florida Department of Agriculture and Consumer Services (FDACS) and provide their organic acreage and production estimates. The total registered organic citrus acreage compiled by FDACS is 4,810 acres for the 2003-04 season. Our study provides acreage estimates for the 2002-03 and 2003-04 seasons based on interviews with growers, and a prediction for 2004-05 acreage.

Acreage estimates from the three different sources are presented in Table 6-1.

Table 6-1. Estimated acreage for certified organic citrus in Florida by season

Season	USDA ^a	FDACS ^b	Our study
1997	2,296	--	--
2000	2,927	--	--
2001	6,056	--	--
2002-2003	--	--	4,150
2003-2004	--	4,810	4,720
2004-2005 ^c	--	--	5,926

^a Source: USDA-ERS.

^b Source: FDACS (personal communication).

^c Predicted acreage based on current acreage plus acreage in transition that is due to be fully certified by the 2004-2005 season. This estimate assumes no current growers give up their certification or reduce their certified acreage.

Our survey estimate for 2003-04 corresponds closely with the FDACS acreage figure. The small discrepancy of 90 acres may result from a technical issue of when some transitional groves became fully certified. The 2004-2005 acreage is a prediction based on survey data of current (2003-04) acreage plus transitional acreage due to become fully certified next season. It is possible that not all transitional acreage was identified (suggesting that actual acreage could be higher than predicted). The prediction,

however, does not account for growers that may give up organic citrus or reduce their acreage (suggesting that actual acreage could be lower than predicted).

It is not known why the USDA acreage estimate for 2001 (6,056 acres) is so much higher than other years. Either numerous groves became fully certified for the first time in 2001, but then exited a year later, or much of this acreage was not legitimate.

Anecdotal evidence indicates that fraud has been a problem in the Florida organic citrus sector. It is thought that the introduction of the national organic standard in 2002 and greater oversight by the DOC and FDACS starting in 2003 have eliminated or reduced the problem of fraud.

Organic citrus is still a relatively small portion of total citrus acreage in Florida. The 4,150 certified organic citrus acreage estimate represents 0.58% of total citrus bearing acreage (718,100 acres) in Florida in 2002-03.

Table 6-2. Regional distribution of organic citrus acreage.

Region	Estimated 2003-04 Organic Acreage ^g	2002-03 Total Citrus Acreage ^f	Percent Organic
North ^a	96	199	48.0%
Central ^b	1,813	300,903	0.6%
Indian River ^c	2,184	168,830	1.3%
Southwest ^d	620	90,858	0.7%
South ^e	3	388	0.8%
Other Counties	0	235,362	0%

^a North region is Putnam County.

^b Central region includes Polk, Highlands, Lake, Osceola, Hardee, Hillsborough, and Pasco counties.

^c Indian River region includes Indian River, St. Lucie, Brevard, and Okeechobee counties.

^d Southwest region includes DeSoto and Charlotte counties.

^e South is Miami-Dade County.

^f Source: FASS; represents total commercial citrus acreage (higher than bearing acreage).

^g The location of four organic acres is unknown.

The regional distribution of organic citrus acreage in 2003-04 based on our survey results is provided in Table 6-2. The Indian River region accounts for the largest organic citrus acreage, followed closely by the Central region. The regional distribution of all citrus acreage (conventional and organic) in 2002-03 is provided in Table 6-2 for comparison. Using the 2003-04 organic citrus acreage estimates and the actual 2002-03 total citrus acreage reported in the Citrus Summary 2002-03, the organic percentage is estimated for each region. The north region (Putnam county) has the highest percentage of organic citrus, with organic acreage accounting for almost one-half of total citrus acreage. The Indian River region is a distant second for organic percentage.

Yields and Production Volumes

Yield figures were only obtained from a few growers, and these figures varied widely. Yields are determined as much by economic factors as by horticultural constraints. In addition to weather, soil type, and biological factors, specific grower practices affect yields. A grower's choice of grove care practices and input intensity depend on grower resources and preferences, individual knowledge and skill, input and output prices, and other market conditions. Yields are reported in field boxes, which hold 1.6 bushels of fruit.

For conventional red grapefruit, the average 2002-03 yield was 395 boxes per acre (FASS). Organic growers reported red grapefruit yields ranging from 27 boxes per acre (for a very low cost grower with sparsely planted trees) to 250 boxes per acre (for a medium cost grower) to 1000 boxes per acre (for a high cost grower). Valencia yields were reported ranging from about 200 to 414 boxes per acre among organic growers, whereas the average conventional Valencia yield for 2002-03 was 299 boxes per acre (FASS). Organic tangerine yields of 100 boxes per acre and 298 boxes per acre were

reported. The average conventional yield for tangerines in 2002-03 was 253 boxes per acre.

As part of the new organic citrus registration program, growers are required each season to provide estimates of their organic production for that season. The organic production estimates for the 2003-04 season are listed by variety in Table 6-3.

Insufficient data was collected to estimate production volumes for other years.

Table 6-3. 2003-04 organic production estimates by variety.

Variety	Number of field boxes (1.6 bushels)
Valencias	282,900
Hamkins	233,050
Red Grapefruit	142,500
White Grapefruit	46,500
Tangerines	44,800
Sunburst	27,240
Pineapple Oranges	25,000
Tangelos	21,000
Satsumas	5,900
Temples	1,220
Honey Bells	600
Other	3,020
Total	833,730

Source: FDACS, personal communication.

Valencia and Hamlin oranges and red grapefruit are varieties with the largest organic production volumes in Florida. Red grapefruit and tangerines represent a higher portion of total organic citrus production than of total conventional citrus production (FASS). Total estimated organic citrus production for the 2003-04 season is 833,730 boxes.

Market Channels

Florida citrus is sold through a variety of market channels. Retail outlets include major supermarket chains, specialty supermarkets, natural food stores, and food cooperatives. Some fruit is sold directly to consumers through farmers markets, roadside

stands, or Internet sales. Florida citrus is exported to Europe and Japan as well. Fresh eliminations or #2 grade fruit are sold to processors for juicing, to retail stores with “fresh squeezed” juice machines, nonprofit organizations, or low-income outlets.

Organic citrus is more likely to be grown for fresh market outlets than conventional Florida citrus. Based on the responses of 23 growers, we estimate that 53% of Florida organic citrus acreage is intended for the fresh market, while 47% is intended for processing. This allocation is much different than the conventional allocation between fresh and processed. Roka estimated that only between 23% and 26% of conventional citrus in Florida is intended for the fresh market. The actual percentage of fruit that is sold fresh is significantly lower, after eliminations are subtracted.

Whereas 108 citrus packinghouses and 52 citrus processing plants were in operation in Florida in 2000 (Hodges et al.), only eight certified organic packinghouses and five certified organic processing plants were identified in this study as active in 2003-04. These figures include one certified entity that has both a packinghouse and processing plant. In addition, four intermediate handlers (including brokers, distributors, and bottlers) are certified to handle organic citrus.

All five processors contacted handle conventional citrus as well as organic. Of seven packers interviewed only two have conventional lines in addition to their organic lines. Three out of four intermediate handlers work with conventional as well as organic citrus.

Seven of the eight packers own or manage groves, and two processors own or manage groves. None of the intermediate handlers own or manage groves.

Two packers handle mostly their own fruit. One packer packs exclusively for one grower. Two other packers handle significant volumes from several different growers. No response was obtained from the remaining three packers on this issue. Four out of five processors obtain significant volumes from a variety of different growers.

Most organic growers sell their fruit to a packinghouse or processing plant. The packer or processor then arranges sales to wholesalers, retailers, or export outlets. A variety of different terms of sale are used. Among growers who do not own a packinghouse or processing plant, single year or multi-year on-tree contracts with packers or processors are common. On-tree contract prices are not necessarily tied to the packout rate. Some growers sell on the cash/spot market. Other less common sales arrangements for growers include wholesale price minus a fixed packing and marketing fee.

Packout rates vary considerably, not only with the quality of the fruit, but also with the requirements of different markets. Packout rates ranging from 30% to 90% were reported. Most growers and packers indicated that eliminations go into organic juice. One grower reported that sometimes eliminations go into conventional juice. Some eliminations or #2-grade fruit is sold to stores with juice machines, nonprofit organizations, or low-income outlets. One grower reported receiving \$2 per box for grapefruit eliminations.

Three growers reported receiving on-tree prices for grapefruit of \$5 to \$6 per field box. Two growers reported tangerine prices ranging from \$8 to \$10 dollars per field box. For processed citrus, growers often receive a delivered-in price per pound solid, from which "pick & haul" costs, taxes and fees are subtracted. Four growers reported delivered-in prices ranging from \$1.25 to \$1.45 per pound solid for juice oranges.

The Rodale Institute collects and posts weekly wholesale prices for organic and conventional fruits and vegetables. A sample of five weekly average prices between October 2003 and April 2004 ranged from \$33.00 to \$19.50 for a 48-count carton of Ruby (red#23) grapefruit. The price premium ranged from 105% to 189% above the conventional price with an average premium of 157%. Prices are also posted for navel oranges and honey tangerines. The origin of the fruit is not reported.

Specific figures on organic citrus volumes to different markets could not be obtained. Interviews with growers, packers, and processors suggest that most fresh organic citrus is shipped to supermarket chains, specialty supermarkets, and natural food stores in major urban centers on the East Coast and Midwest. Some fresh citrus is exported to Europe and Japan. A small percentage of organic citrus is sold locally or direct to consumers through farmers markets, roadside stands, food cooperatives, and Internet sales. Processed citrus is sold as organic orange juice or grapefruit juice through retailers nationwide. Also, some organic citrus juice is exported to Europe and Japan.

The small number of organic packers and processors and anecdotal evidence suggest that market channels for organic citrus are not perfectly competitive. Different market outlets have different volume and quality requirements, and support different price levels. Some channels may restrict entry or limit volumes in order to maintain a substantial price premium. Reports from Europe indicate that despite an organic price premium, substantial amounts of organic citrus are sold on the conventional market (Juliá and Server; Liu). Although none of the Florida organic citrus growers report selling fruit as conventional (except eliminations in some cases), some growers complain of difficulty finding suitable markets for their organic citrus and have let fruit drop without harvesting.

Others report that intermediate handlers try to control organic citrus markets and that large consolidated distribution channels reflecting retail purchasing structures can make it difficult for small growers to access major retail markets, including local supermarkets.

Grove and Grower Characteristics

Thirty five growers were identified as having certified organic citrus acreage in the 2002-03 or 2003-04 seasons (27 of these had certified acreage in 2002-03 and 31 had certified acreage in 2003-04). Of these 35 growers, 28 agreed to be interviewed. Four others were contacted by telephone, but declined to be interviewed. The remaining three could not be contacted. Organic citrus grove acreage was obtained for all 35 growers either directly from grower responses, from their certifying agent, or from FDACS. Results reported in this section are based on 2002-03 and 2003-04 certified growers only.

Farm Sizes

Organic grove sizes vary widely. Of 35 growers with certified organic citrus acreage in either the 2002-03 or 2003-04 seasons, organic grove sizes ranged from less than one acre to 1,165 acres. For the purposes of this study, one grower refers to one certified entity, which may encompass more than one land owner. The mean acreage owned or managed by one certified entity, whether contiguous or not, is 148 acres in this sample. The median acreage is 63 acres. That is, one-half of growers have organic citrus groves that are 63 acres or less. Fourteen growers (40%) have groves of 25 acres or less.

Figure 6-1 shows the number of growers in each grove size category (25 acre increments). For example, 14 growers have organic citrus acreage between 0 and 25 acres, 2 growers have organic citrus acreage between 26 and 50 acres, and 7 growers have acreage between 51 and 75 acres.

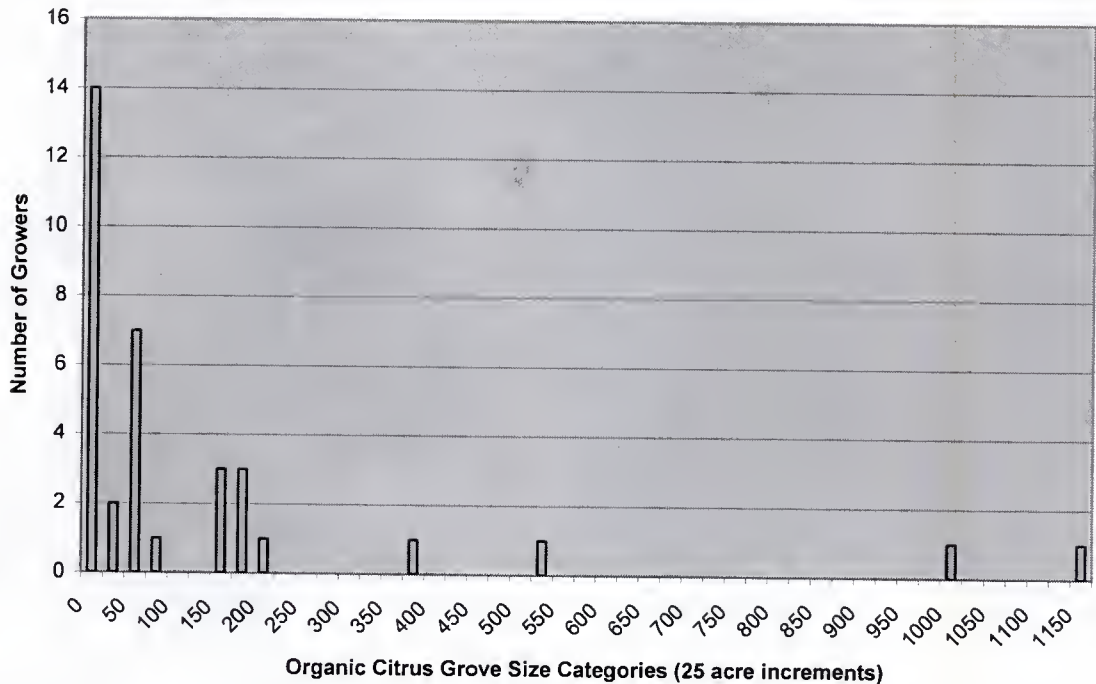


Figure 6-1. Distribution of groves by size category.

Other Grower Characteristics

Most growers are exclusively organic, but some combine organic and conventional operations. Nine of twenty eight growers responding (32%) reported having conventional citrus acreage in addition to their organic groves. Several growers also grow other crops besides citrus or raise livestock, either organically or conventionally. Two small growers reported having polyculture systems, in which other organic tree crops are mixed together with organic citrus on the same land.

The majority of organic citrus growers own their citrus land, but some lease land. Of the 26 growers responding to this question, 6 growers (23%) lease some or all of their organic citrus land.

A variety of business structures are found among organic citrus growers. These include family businesses, family partnerships, nonfamily partnerships, cooperatives,

limited liability companies, conventional “c” corporations, and subchapter “s” corporations. Of 13 responses to the question of business structure, 7 growers (54%) consider their organic citrus enterprise a family business or partnership, 5 growers (38%) have the status of a corporation, and 1 has a cooperative structure.

Most organic growers have been growing citrus for many years. Eleven of sixteen growers or managers answering this question (69%) have been growing citrus (conventional or organic) for at least fifteen years. Five of these sixteen (31%) have been growing citrus for thirty or more years.

Fewer respondents have been growing citrus organically for very long. Of 29 growers answering the question, 21 growers (72%) have not been continuously certified organic for more than five years (since before 1999). Four (14%) have been continuously certified since 1998, but not since 1993. Another four (14%) have been continuously certified since 1993 or before.

Organic certification typically is obtained on mature, established groves. Of 26 responses to the question of how the transition to organic was made, fifteen (58%) made a direct transition from conventional citrus to organic citrus, eleven (42%) bought or took over an established grove (either conventional or organic) and immediately started managing it organically. None of the 26 respondents reported starting an organic citrus grove entirely from new plantings of young trees.

Of 28 growers responding, seven have their own packinghouse and two own a processing plant in addition to their citrus groves. Most growers are not vertically integrated and sell their fruit to a packer or processor.

Organic Citrus Grower Typology

Organic citrus growers are a diverse group with a wide variety of characteristics. Five general farm types are identified. Although not all growers fit neatly into one particular category, these descriptions are useful for capturing a range of different farm types and some essential differences between them. The categorization of farm types is based on the following characteristics:

1. Organic acreage and total farm size
2. Whether conventional citrus is part of the enterprise
3. Ownership of packing or processing facilities and connection to the market
4. Production cost and input intensity
5. Yields
6. Ownership vs. lease of the land
7. Business structure
8. If the owner lives on the farm, does significant grove work, or is actively involved in grove management
9. If the grove is managed for the long-run (as determined by replanting and input intensity)
10. Reliance on off-farm employment.

Type 1 farms are large citrus operations (500 total citrus acres or more) that appear to be in business for the long-run. These farms have converted some acreage to organic, but also maintain significant conventional acreage. Organic management is used as a temporary interval in a grove's lifecycle. They prefer to establish young groves under conventional management, and convert some groves to organic once they are mature. With medium or high organic grove care costs, medium or high yields are obtained. Most of these operations are well connected to the market, and own a packing or processing facility. Typically having a corporate or cooperative business structure, these enterprises have started organic lines as part of their marketing strategy in response to increasing demand for organic products.

Type 2 farms are groves ranging from 25 acres to more than 1000 acres that run low cost grove operations and do not appear to be managing groves to sustain long-term yields. They may be exclusively organic, mixed organic and conventional, or combine citrus with other agricultural activities. Groves are managed organically as a short-term bridge between conventional management and sale of land or conversion to other use. Abandoned conventional groves may be acquired for this purpose. Organic certification is obtained rather quickly when no conventional inputs have been applied for three years prior to purchase or lease. Organic fruit is sold in an attempt to extract some returns from land in the short-run. High input investment does not make sense if land will be sold or converted to another use within a few years. Yields are low. Land may be owned or leased. These growers typically have a corporate business structure. Some have their own packing facility and strong market connections, and others do not.

Type 3 growers have organic citrus groves ranging from 60 to 200 acres, and are trying to sustain organic citrus production as a major part of their business, possibly with other agricultural activities, but not with conventional citrus. Agriculture is their primary source of income, and organic citrus is an integral part of their farm enterprise. These groves usually are managed with a medium or high cost program. The owner may or may not be actively involved in management or grove work. These farms do not have their own packing or processing facility, and they lack strong market connections.

Type 4 farms are small growers (less than 25 acres) with medium or high grove care costs and medium or high yields. Groves are managed intensively for the long-run. The land is owned, not leased, and the grower typically lives on the farm and contributes significant amounts of his own labor to grove care. Even while relying on own labor and

management knowledge, costs tend to be high due to a conscious attempt to maintain high yields or due to a lack of economies of scale. They rely on off-farm work for a significant amount of their household income. Most of these growers do not have conventional groves in addition to their organic groves. With one exception, these growers do not own a packing or processing facility. Most sell their fruit to a packer or processor, and a small portion of fruit may be sold direct to consumers.

Type 5 farms are small growers (less than 25 acres) with low production costs and low or medium yields. Either they are risk averse and do not have enough confidence in methods that could boost yields profitably, or they are financially constrained, or possibly just very efficient. Unlike Type 2 growers, these growers intend to maintain land in organic production for the long-run. They do not have conventional groves, but some use a polyculture system with other types of fruit trees mixed together with their citrus. They own the land, live on the farm, and use significant amounts of their own labor for grove work. These farms typically are single family businesses or family partnerships. They do not have their own packing or processing facility, so they sell either to a packer or processor or direct to consumers.

Sufficient data was collected from 23 organic citrus growers to categorize them into one of the five farm types. The highest percentage of growers (30%) fit best in the Type 2 category; 22% are Type 3 farms; 17% are Type 1 farms; 17% fit Type 4; and 13% fit the Type 5 characterization. Based on the 23 growers characterized, the highest percentage of land in organic citrus production fits best in Type 1 (45%), followed by Type 2 (38%), Type 3 (16%), Type 4 (1%), and Type 5 (1%).

Grove Care Practices, Costs, and Profitability

Organic agriculture refers to holistic farming systems that “respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity” (USDA-AMS 2002, p.E6). The USDA implemented a national organic standard for agricultural production and handling in 2002. This standard provides general guidelines for organic certification and includes a list of allowed and prohibited substances (USDA-AMS 2002). Within the organic guidelines, growers are given considerable leeway to tailor individual practices to their site-specific, economic, and agronomic circumstances.

In this section, grove care practices utilized by organic citrus growers are described. Production costs are estimated for different grove care programs, and profitability analysis is conducted.

Organic Grove Care Practices

Consistent with the variety of organic citrus enterprises, grove care practices and costs varied widely among growers. Eighteen growers were asked to describe their specific nutrient management, weed management, and other pest management practices in an open-ended format. Growers were also asked what type of irrigation system was in their organic citrus groves. Responses are categorized and tabulated in Table 6-4.

Poultry manure is the most common primary nutrient source among organic citrus growers. Several growers combine urban plant debris with poultry manure at ratios of 3:1 or 5:2. A majority of growers use fish emulsion as a foliar spray for tree nutrition and some pest control benefits, and several growers use additional sources of micronutrients often in the form of a liquid foliar spray. Some growers use organic bulk blend fertilizers or leguminous ground covers as an integral part of their nutrient management. A few

growers also report using potash, dolomite, horse manure, feather meal, or colloidal phosphate.

Table 6-4. Organic grove care practices.

Nutrient management	Number of growers (out of 18)	Percentage of growers (out of 18)
Poultry manure	13	72%
Fish/seaweed emulsion	10	56%
Urban plant debris	5	28%
Micronutrients	5	28%
Ground cover / green manure	3	17%
Organic bulk blend fertilizer	3	17%
Potash	3	17%
Dolomite	2	11%
Horse manure	2	11%
Feather meal	1	11%
Colloidal phosphate	1	11%
Weed Management		
Mechanical mowing	18	100%
Hand weed / hand hoe	17	94%
Disk &/or chop	9	50%
Ground cover	5	28%
Mulch	3	17%
Tree hoe	3	17%
Organic sprays	2	11%
Other Pest Management		
Fish/seaweed emulsion	10	56%
435 (petroleum-based) oil	7	39%
No other pest management	4	22%
Copper	3	17%
Mechanical tillage/disk	2	11%
Beneficial insect release	2	11%
Vegetable oil	1	6%
Organic miticide	1	6%
Sulfur	1	6%
Irrigation System		
Microjet/microsprinkler	13	72%
Flood	2	11%
Drip	2	11%
Watertruck	1	6%
Hose from house	1	6%
None	1	6%

In organic groves, weed management requires substantial amounts of mechanical and hand labor. All respondents mow, and all but one hand weed or hand hoe. Half of respondents disk, or disk and chop, as a major weed control activity. Some growers also use ground covers, mulches, tree hoes, or organic sprays.

In addition to fish emulsion, which reportedly has some pest control benefits, several growers use petroleum-based oil sprays as a major part of their pest control routine. A few growers report using copper, disking, beneficial insect releases, vegetable oil, organic miticide, or sulfur to control insect pests or fungus. Interestingly, 4 respondents (22%) report using no pest management practices (i.e., in addition to weed control).

Microjet irrigation systems are the most common. A few organic growers use flood, drip, watertruck, or other irrigation systems on all or part of their property. Only one grower reported no irrigation system.

Most organic groves are owner (or lessee) managed. Sixty percent of twenty responding growers report that they never use a grove care company. Forty percent of responding growers report that they sometimes use a grove care company for certain practices. Only twenty percent of growers rely primarily on a grove care company for grove care.

Organic Grove Care Costs

Grove care costs were provided by some growers and calculated for the remaining growers who provided detailed information on grove care practices. Costs vary widely among organic citrus growers. A distribution of estimated grove care costs among 18 growers is shown in Table 6-5.

Table 6-5. Distribution of growers among grove care cost categories.

Grove care cost category ^a	Number of growers (out of 18)	Percentage of growers (out of 18)
\$1000-\$1250	7	39%
\$800-\$999	3	17%
\$600-\$799	3	17%
\$400-\$599	1	6%
\$399 or less	4	22%

^a Annual per acre variable (direct) grove care cost.

Grove care cost estimates reported here represent variable production costs only. They include materials, labor, fuel, equipment maintenance and repair for the following activities: nutrient management, weed management, other pest management activities, pruning, irrigation maintenance, and tree replacement of 3-4 trees per acre per year. The grove care cost estimates described in this report do not include harvesting and assessment costs, or fixed costs (indirect expenses) such as machinery depreciation, land charge, taxes and insurance, interest on capital investments, management charge, or the opportunity cost of fixed factors or unpaid labor.

Growers can be grouped into three broader categories: high cost (\$1000-\$1250), medium cost (\$600-\$999), and low cost (\$599 or less). Seven growers fall into the high cost category, six growers are in the middle category, and five growers have low cost programs. Representative production budgets are provided for each of these three grove care cost categories in Table 6-6.

The production budgets in Table 6-6 represent estimated annual grove care costs for maintaining a mature citrus grove (i.e., replacing on average 3-4 trees per year) under three different programs. They are rough averages for growers in each cost category across regions and varieties. The production budgets are hypothetical, since none of the budgets represents a specific grower exactly. The actual combinations of practices used

by individual growers vary widely. Certain combinations of practices were selected for the representative production budgets in Table 6-6, however all growers in the same cost category do not use the same combination of practices.

Table 6-6. Representative production budgets

Grove care practice and unit cost	Amount or frequency			Annual cost per acre		
Cost category:	High	Middle	Low	High	Middle	Low
Weed management						
Mechanical mow (\$10/acre)	5 x	4 x	3 x	\$50	\$40	\$30
Hand weed/hoe/pull vines (\$12/hour)	25 hrs	14 hrs	7 hrs	\$300	\$168	\$84
Mechanical hoe/disk/chop (\$10/acre)	3 x	2 x		\$30	\$20	
				\$380	\$228	\$114
Other pest management						
435 Oil (\$2/gal)	8 gal	4 gal		\$16	\$8	
Copper (\$1.50/lb)	10 lbs			\$15		
Application (\$25/application)	2 x	1 x		\$50	\$25	
				\$81	\$33	\$0
Nutrient management						
Poultry manure (\$38/ton)		2 tons	3 tons		\$76	\$114
Application (\$8/application)		2 x	2 x		\$16	\$16
Urban plant debris (\$35/ton)		5 tons			\$175	
Application (with manure)						
Fish/seaweed emulsion (\$5/gal)	6 gals	3 gals		\$30	\$15	
Application (\$25/application)	2 x	1 x		\$50	\$25	
Organic bulk blend fertilizer (\$430/ton)	.7 ton			\$301		
Application (\$7/application)	2 x			\$14		
Dolomite (\$12 per 1/3 ton)	1	1		\$12	\$12	
Micronutrients (\$7/gal)	1 gal	1 gal		\$7	\$7	
				\$414	\$326	\$130
Pruning						
(\$36 conventional estimate)	100%	75%	50%	\$36	\$27	\$18
Tree replacement						
3-4 trees (\$90 conventional estimate)	100%	100%	100%	\$90	\$90	\$90
Irrigation						
Microsprinkler (\$145 conventional est.)	1	1		\$145	\$145	
Flood (\$39 conventional estimate)			1			\$39
TOTAL^a				\$1,146	\$849	\$391

Source: Cost estimates are based on data provided by organic grower interviews and conventional rates reported in Muraro, Hebb & Stover; Muraro & Oswalt; Muraro, Roka & Rouse.

^a Total estimated costs are annual per acre variable (direct) expenses for grove care only. They represent rough averages among growers in each cost category and across regions. Actual grower costs vary according to site-specific conditions, farm type, and growing region.

For example, instead of using bulk blend fertilizer as shown in Table 6-6, a high cost grower may use poultry manure and urban plant debris. Alternatively, a medium cost grower may use bulk blend fertilizer and no poultry manure or urban plant debris.

These budgets serve only as a general guide to reflect common practices and costs, calculate profitability, break-even prices or break-even yields. Most cost estimates for materials and application are based on data provided by growers. Some cost data, such as for labor, pruning, tree replacement, and irrigation are obtained from rates reported for conventional citrus budgets in Muraro, Hebb, and Stover, Muraro and Oswalt, and Muraro, Roka, and Rouse.

Organic certification cost is omitted from the budget, as it is a fixed cost associated with organic production. The certification cost depends on certification agent, farm size, sales revenue, and government cost-share reimbursement programs. A 1999 survey of eleven certifying agencies, found average first-year certification costs of “\$579, \$1,414, \$3,623, and \$33,276 for farms with incomes of \$30,000, \$200,000, \$800,000, and \$10,000,000, respectively” (Ferguson, p.2). Currently a national organic certification cost-share program reimburses organic growers up to 70% or \$500 of annual certification costs. Also, paperwork and recordkeeping necessary for organic certification entail additional costs for the grower.

Single Enterprise Profitability Analysis

Production budgets are useful for estimating the profitability of a farming operation or a change in farm plan, and for predicting the effects of changes in agricultural policy. Profitability can be measured in terms of gross margin or income above variable cost. Gross margin is calculated by subtracting variable costs from gross revenue. It represents the per acre return to fixed factors. That is, it does not account for fixed costs, such as machinery depreciation, land charge, taxes and insurance, interest on capital investments, management charge, or the opportunity cost of fixed factors or unpaid labor (Kay and Edwards).

The most basic type of profitability analysis relies on a single production budget and is static with respect to time. Gross margin, average variable cost of production, break-even price, and break-even yield can be calculated using three pieces of information: variable cost per acre, yield per acre, and output price.

The wide variation in grove care costs and yields reported by growers is described above. For example, organic growers reported red grapefruit yields ranging from 27 boxes per acre (for a very low cost grower with sparsely planted trees) to 250 boxes per acre (for a medium cost grower) to 1000 boxes per acre (for a high cost grower). Organic round orange yields were reported ranging from about 201 to 600 boxes per acre among organic growers, and organic tangerine yields of 100 boxes per acre and 298 boxes per acre were reported. Yield figures were not obtained for the lowest cost orange and tangerine growers. Price reports were all similar. Growers reported on-tree prices ranging from \$5 to \$6 for grapefruit and \$8 to \$10 for tangerines (per 1.6 bushel field box). The on-tree price reported for round oranges was \$6 per box. Delivered in prices for processed oranges were reported ranging from \$1.25 to \$1.45 per pound solid.

Given the estimates of costs, yields and prices for low, middle, and high cost growers, gross margin and average variable production cost are calculated for organic grapefruit in Table 6-7, round oranges in Table 6-8, and tangerines in Table 6-9. The margins and costs presented in the tables do not include harvesting costs, assessment fees, or fixed costs. Costs and yields vary widely, and the values in Tables 6-7, 6-8, and 6-9 do not represent any particular grower. Therefore the numbers should be treated as hypothetical.

Table 6-7. Gross margin and average variable cost estimates for organic grapefruit

Cost category	Variable grove care cost (per acre)	Yield (per acre)	Price (per box)	Gross margin (per acre)	Average var. cost (per box)
High	\$1,146	450	\$5.67	\$1,406	\$2.55
Middle	\$849	300	\$5.67	\$852	\$2.83
Low	\$391	80	\$5.67	\$63	\$4.89

Table 6-8. Gross margin and average variable cost estimates for organic round oranges

Cost category	Variable grove care cost (per acre)	Yield (per acre)	Price (per box)	Gross margin (per acre)	Average var. cost (per box)
High	\$1,146	400	\$6	\$1,254	\$2.87
Middle	\$849	250	\$6	\$651	\$3.40
Low	\$391	70	\$6	\$49	\$5.59

Table 6-9. Gross margin and average variable cost estimates for tangerines

Cost category	Variable grove care cost (per acre)	Yield (per acre)	On-tree price (per box)	Gross margin (per acre)	Average var. cost (per box)
High	\$1,146	300	\$9	\$1,554	\$3.82
Middle	\$849	200	\$9	\$951	\$4.25
Low	\$391	60	\$9	\$149	\$6.52

For a particular cost category, gross margins are similar for the three varieties of citrus. Gross margins are highest for the high cost category and lowest for the low cost category. It is apparent from these calculations that more intensive grove care pays off for growers who can support the necessary investment and bear the risk. Assuming that growers can obtain above average yields by managing groves more intensively (in the medium to high cost range), the resulting improvement in returns more than offsets the increased grove care expenses.

Average (per box) variable costs are lowest for the intensively managed (high cost) representative grove. Average variable cost equals the minimum price necessary to just cover variable costs. The distribution of average variable costs among growers provides

an indication of short-run supply. Only the growers with an average variable cost at or below a given price would be willing to continue producing in the short-run.

Given the considerable variation in grower costs and yields, calculation of break-even yields for a range of prices or break-even prices for a range of yields can aid growers in forming “their own expectations about the probability of obtaining a price and yield combination that would just cover total costs” (Kay and Edwards). Short-run break-even yields and break-even prices based on variable grove care costs are shown in Tables 6-10 and 6-11. Short-run break-even yield is the yield needed to just cover variable costs, which is where gross margin equals zero. Short-run break-even price is the on-tree price needed to just cover variable costs, which is where the gross margin equals zero.

Table 6-10. Short-run break-even yields (boxes per acre)

Variable grove care costs (per acre)	On-tree price of \$5 per box	On-tree price of \$6 per box	On-tree price of \$7 per box
\$300	60	50	43
\$500	100	83	71
\$700	140	117	100
\$900	180	150	129
\$1100	220	183	157

Table 6-11. Short-run break-even prices (\$/box)

Variable grove care costs (per acre)	Yield of 50 boxes	Yield of 100 boxes	Yield of 150 boxes	Yield of 200 boxes	Yield of 250 boxes	Yield of 300 boxes
\$300	\$6.00	\$3.00	\$2.00	\$1.50	\$1.20	\$1.00
\$500	\$10.00	\$5.00	\$3.33	\$2.50	\$2.00	\$1.67
\$700	\$14.00	\$7.00	\$4.67	\$3.50	\$2.80	\$2.33
\$900	\$18.00	\$9.00	\$6.00	\$4.50	\$3.60	\$3.00
\$1100	\$22.00	\$11.00	\$7.33	\$5.50	\$4.40	\$3.67

According to the calculations shown in Table 6-10, a typical high cost grower (\$1100 per acre) would need a yield of at least 220 boxes per acre to just cover variable

costs with an on-tree price of \$5 per box. The figures in Table 6-11 demonstrate that the same high cost grower who obtains a yield of 200 boxes/acre would need to receive an on-tree price of \$5.50 per box to just cover variable costs.

Partial Budgets

Sometimes a grower would like to anticipate the effect on profits of making a change to his farm operation. Partial budgets are used to calculate the expected change in profit that would result from changing a farm plan or adopting a new farming system (Kay and Edwards). Two different types of production methods, such as conventional and organic, can be compared using partial budgets. A partial budget sums additional costs, reduced costs, additional revenue, and reduced revenue associated with a change in farm plan to calculate the net change in average profit (Kay and Edwards). In order to create partial budgets for comparing conventional and organic production, data on costs, yields, and prices for both systems are needed.

Conventional production budgets by region and variety for the 2002-03 season are reported in Muraro, Hebb, and Stover, Muraro and Oswalt, and Muraro, Roka, and Rouse. Representative grove care costs for conventional citrus ranged from \$723 to \$916 per acre for conventional oranges and from \$697 to \$1,025 per acre for conventional grapefruit depending on growing region.

Average per acre yields for all Florida regions over the last five seasons (1998-99 through 2002-03) are reported as 360 boxes for conventional round oranges, 433 boxes for conventional grapefruit, and 239 boxes for conventional tangerines (FASS). Average on-tree prices per box over the last five seasons are reported as \$3.70 for conventional round oranges, \$2.29 for conventional grapefruit, and \$8.29 for conventional tangerines (FASS).

Table 6-12. Partial budget comparing conventional and organic grapefruit in the Indian River region under high-cost, fresh, cultural programs

	Conventional grapefruit^a	Organic grapefruit^b	Change in gross margin^c
On-tree price (per box)	\$3.06	\$5.67	
Yield (boxes per acre)	417	350	
Total revenue (per acre)	\$1276	\$1985	+\$709
Grove care category			
Weed management	\$211	\$380	-\$169
Other pest management	\$339	\$81	+\$258
Nutrient management	\$120	\$414	-\$294
Pruning	\$43	\$43	no change
Tree replacement	\$128	\$128	no change
Irrigation	\$184	\$184	no change
Total variable cost	\$1025	\$1230	-\$205
Total gross margin	\$251	\$765	+\$504

^a Prices, yields, and costs for conventional grapefruit obtained from Muraro, Hebb, and Stover; rounding errors account for slight differences in figures.

^b Costs differ slightly from the high cost production budget in Table 9, as some costs are specific to Indian River grapefruit.

^c A plus sign represents greater revenue or lower costs for organic; a minus sign represents lower revenue or greater cost for organic.

An example shown in Table 6-12 compares a typical fresh fruit (high cost) cultural program for conventional Indian River Grapefruit with a hypothetical high cost organic grapefruit cultural program. Despite higher per acre grove care costs for organic grapefruit (when comparing fresh—high cost—cultural programs) and lower expected yields, gross margin is significantly higher in the representative partial budget shown in Table 6-12. The greater profitability of organic grapefruit in this example is due to the low price of conventional grapefruit and the organic price premium of nearly 100% (on-tree). If the organic price were to fall below \$4.23 (38% on-tree premium), the organic gross margin would be less than the conventional gross margin of \$251 for the yields, costs, and conventional price in this example.

Table 6-13. Partial budget comparing conventional and organic Valencia oranges in the central region under medium-cost cultural programs for processed market^a

	Conventional oranges^a	Organic oranges^b	Change in gross margin^c
Delivered-in price (per P.S.)	\$1.05	\$1.35	
On-tree price (per P.S.)	\$0.70	\$0.98	
Pounds solid per box	6.7	6.3	
On-tree price (per box)	\$4.69	\$6.17	
Yield (boxes per acre)	446	365	
Total revenue (per acre)	\$2092	\$2252	+\$160
Grove care category			
Weed management	\$220	\$228	-\$8
Other pest management	\$214	\$33	+\$181
Nutrient management	\$158	\$326	-\$168
Pruning	\$36	\$27	+\$9
Tree replacement	\$63	\$63	no change
Irrigation	\$145	\$145	no change
Total variable cost	\$836	\$822	+\$14
Total gross margin	\$1256	\$1338	+\$174

^a Prices, yields, and costs for conventional grapefruit obtained from Muraro and Oswalt; rounding errors account for slight differences in figures.

^b Costs differ slightly from the high cost production budget in Table 9, as some costs are specific to central region Valencia oranges.

^c A plus sign represents greater revenue or lower costs for organic; a minus sign represents lower revenue or greater cost for organic.

Table 6-13 presents a partial budget comparing conventional Valencia oranges with organic Valencia oranges in the central region. In this example, revenue and costs are quite similar for the two different production methods. Given these representative costs, yields, and prices, organic Valencia oranges have a gross margin that exceeds that of conventional Valencia oranges by \$174. The price premium for processed organic Valencia oranges is not as large as the premium for organic grapefruit. The typical on-tree price premium per box for organic Valencia juice oranges is 32%. This figure assumes 6.7 pounds solid per box for conventional Valencia oranges and 6.3 pounds solid per box for organic Valencia oranges. Some growers and processors claim that organic

pounds solid per box are higher than conventional, while others claim that pounds solid are about the same or lower for organic oranges. Based on specific records obtained from two growers of organic Valencia oranges, 6.3 pounds solid per box is typical. Muraro and Oswalt report 6.7 pounds solid per box for conventional Valencia oranges. Given the yields, costs, and conventional price for Valencia oranges in this example, organic Valencia oranges would have a lower gross margin if the organic on-tree price per box fell below \$5.69 (a premium of 20% per box). This price translates to a delivered-in price of \$1.28 per pound solid.

In the partial budget calculations, on-tree prices are assumed to be unaffected by packout rates. For organic citrus, it is not uncommon for growers to receive a fixed on-tree price regardless of packout rate. This assumption may be less realistic for conventional citrus.

Break-even prices and break-even yields also can be calculated for partial budgets. Given a particular organic price premium, partial break-even yield identifies the maximum drop in yield under organic management that would support an organic gross margin at least as high as the conventional gross margin. For the organic gross margin to exceed the conventional gross margin, given an organic price premium of 30%, the conventional yield must be no more than 30% higher than the organic yield (assuming per acre production costs are the same).

The partial budgets presented above represent our best judgment regarding typical prices, yields, and variable production costs over the last two years. As with the representative production budgets, these figures do not correspond to any one grower in particular. The actual differences in gross margin for specific groves will vary widely

according to grower and farm characteristics. Also, these partial budgets do not include any changes in fixed costs, such as organic certification costs or the costs of additional recordkeeping and paperwork required for certification. Furthermore, this static analysis does not consider the three-year transition period, in which yields may fall considerably, but an organic price premium cannot be obtained.

For perennial fruit crops, like citrus, static budgets do not capture the changes in profitability over the entire life cycle of the crop. It takes several years after a grove is first planted for the trees to produce significant yields. Likewise, the three-year conversion period required for organic groves represents a special interval with typically declining yields and no price premium. Static budgets like those presented above should ideally include a prorated share or amortization of costs incurred during grove establishment or the conversion period. Establishment costs are partially captured in the budgets described above by requiring annual replacement of 3-4 trees. Investment analysis can add more detail regarding the effects of changes over time.

Investment Analysis

The establishment of a grove or the decision to convert to organic management is an investment that requires short-term costs with the expectation of future returns. Investment analysis is appropriate for assessing the profitability of such investments, in which costs and revenues are generated unevenly over time (Kay and Edwards).

Juliá and Server conduct an investment analysis for organic citrus in the Valencia region of Spain. The authors calculate the net present value, internal rate of return, and investment recovery period (or payback period) for typical organic and conventional citrus groves. They consider a 25-year time horizon, in which the grove is newly planted in the first year, and the organic grove is converted from conventional management in the

tenth year. Based on Spanish citrus data, they estimate that organic yields fall to 81% of conventional yields during the first four years after conversion, but then rise to 90% of conventional yields for the remaining years of organic management. They calculate total costs per hectare to be 37% higher for organic oranges than for conventional oranges during sustained management (years 11-25). In their study, labor costs and fertilizer costs are higher, but irrigation, insecticide, fungicide, and herbicide costs are lower under organic management. Using a 29% price premium for organic oranges, they estimate the net present value and internal rate of return to be slightly higher for the conventional grove than for the organic grove. Also, the investment recovery period is slightly shorter for the conventional grove. They conclude that a 30% price premium is necessary for the internal rate of return on the organic grove to exceed that of the conventional grove. The results of this Spanish study seem roughly consistent with figures gathered in the present study of Florida citrus, at least for a high-cost/medium-yield organic grove.

Incentives, Disincentives, and Alternatives

Reasons for Growing Organically

Although gross margin or profit is typically an important consideration, other factors may affect growers' decisions on a particular farm plan and method of farming. These might include various types of risk, cash or credit constraints, expectations regarding legal liability issues, environmental perceptions and preferences, or health concerns.

Growers were asked the question: "What were the primary reasons you decided to grow organically, instead of conventionally?" First, their open-ended responses were recorded. The following paraphrases are a selection of open-ended responses to the question about their primary reasons for growing organically.

- I'm tired of chemicals; if others had to do their own spraying, they'd get tired of them too.
- I believe in it, and I'm concerned for the health and safety of my workers.
- I noticed that conventional fertilizer would burn my hands, and I was concerned about flora and fauna, the soil and the environment. It seemed like a good idea to let the soil revert to its natural state.
- My grove borders duplexes and high class homes and I already knew of some environmental liability problems. I wouldn't go back to conventional—chemicals kill everything, including beneficial insects.
- Because that was what I wanted to eat—better for health of plant and people.
- Primarily economic, secondarily health and the environment
- Returns, prices
- I didn't have the money to push grapefruit and replant, and conventional grapefruit wasn't making any money. I decided to fill out the paperwork to sell it as organic. I don't believe in the organic concept.
- Because of economics
- The economics are better.
- I don't know any other way.

After being given the chance to respond to the open-ended question, growers were presented with a list of possible factors that could influence a grower's decision to grow organically, and were asked to rate the importance of each factor in their decision.

Thirteen responses were obtained rating the list of factors. The distribution of scores and the mean score on a zero-three scale (0=not important or not applicable, 1=slightly important, 2=moderately important, 3=very important) are reported in Table 6-14.

Table 6-14. Importance of factors in growers' decision to adopt organic methods

	Not Important (0 points)	Slightly Important (1 point)	Moderately Important (2 points)	Very Important (3 points)	Total Points	Mean Score
Price premiums	<i>1</i>	<i>0</i>	<i>5</i>	<i>7</i>	31	2.38
Environ. concern	<i>3</i>	<i>2</i>	<i>2</i>	<i>6</i>	24	1.85
Health concern	<i>5</i>	<i>1</i>	<i>3</i>	<i>4</i>	19	1.46
Environ. liability risk	<i>6</i>	<i>3</i>	<i>2</i>	<i>2</i>	13	1.00
Reduce costs	<i>9</i>	<i>2</i>	<i>1</i>	<i>1</i>	7	0.54
Environ. regulations	<i>11</i>	<i>1</i>	<i>1</i>	<i>0</i>	3	0.23
Credit difficulties	<i>13</i>	<i>0</i>	<i>0</i>	<i>0</i>	0	0.00

Note: Numbers in italics represent the number of growers indicating the level of importance matching the column heading for each factor (13 responding growers).

Not surprisingly, the organic price premium was rated as the most important incentive, on average, followed by concern for the environment, concern for personal or family health, and lower risk of environmental liability. Reducing production costs and environmental regulations were relatively insignificant factors, and none of the thirteen respondents assigned any importance (or applicability) to difficulty obtaining credit.

The results demonstrate that the profit motive is a dominant factor influencing the decision of most growers to adopt organic methods. The difference in scores between “price premiums” and “reduce costs” is consistent with data showing that organic growers obtain a sizeable price premium, but that most organic growers have production costs equal to, or greater than, typical conventional costs. Only one of the thirteen respondents attached no importance to either the price premium or reducing production costs. Most organic growers stated that other factors, besides profitability, were important in their decision as well. Concern for the environment, concern for personal or family health, and a perceived lower risk of liability for environmental damages were significant factors for several growers and received average scores falling between “slightly important” and “moderately important.”

Problems and Difficulties

Various risks, difficulties, and obstacles can hinder the adoption of alternative agricultural methods. In order to identify some of the disincentives for organic citrus production, growers were asked: “What are the main difficulties associated with growing certified organic citrus on your land?” Growers’ open-ended responses to the question are listed below:

- Weeds and fire ants
- Not being able to use herbicide

- Nutrition and soil management; also lack of information
- Weeds and nutrition
- Weeds and vines
- Still a small market; limited number of organic packers and processors
- Capital constraints; Brazilian pepper trees
- Fertilization and weed control
- Weeds
- Weeds, vines, and grasshoppers
- Weeds
- Weed control
- Paperwork and finding markets
- Cash flow
- Paperwork and greasy spot
- Fire ants and fertilization
- Weeds, especially Johnson grass and pepper trees
- Weed control
- Paperwork.

After being asked the open-ended question, growers were given a list of possible problems or issues associated with growing organic citrus, and were asked to indicate whether each issue is not a problem, a small problem, a large problem, or a severe problem for them. The distribution of scores and mean score are presented in Table 6-15.

Table 6-15. Difficulties associated with growing certified organic citrus

	Not a Problem (0 points)	Small Problem (1 point)	Large Problem (2 points)	Severe Problem (3 points)	Total Points	Mean Score
Weed problems	<i>1</i>	<i>1</i>	<i>5</i>	<i>8</i>	35	2.33
Market information	<i>4</i>	<i>2</i>	<i>5</i>	<i>4</i>	24	1.60
Finding buyers	<i>4</i>	<i>5</i>	<i>1</i>	<i>5</i>	22	1.47
Labor costs	<i>5</i>	<i>3</i>	<i>4</i>	<i>3</i>	20	1.33
Production info.	<i>7</i>	<i>1</i>	<i>3</i>	<i>4</i>	19	1.27
Soil fert./nutrients	<i>5</i>	<i>2</i>	<i>7</i>	<i>1</i>	19	1.27
Recordkeep/paperwrk	<i>5</i>	<i>3</i>	<i>5</i>	<i>2</i>	19	1.27
Disease problems	<i>5</i>	<i>7</i>	<i>2</i>	<i>1</i>	14	0.93
Insect problems	<i>5</i>	<i>8</i>	<i>1</i>	<i>1</i>	13	0.87
Certification costs	<i>7</i>	<i>5</i>	<i>2</i>	<i>1</i>	12	0.80
Fungus problems	<i>7</i>	<i>6</i>	<i>2</i>	<i>0</i>	10	0.67
Nematode problems	<i>12</i>	<i>3</i>	<i>0</i>	<i>0</i>	3	0.20
Chem. drift/neighbor	<i>14</i>	<i>1</i>	<i>0</i>	<i>0</i>	1	0.07

Note: Numbers in italics represent the number of growers indicating the level of difficulty matching the column heading for each issue (15 responding growers).

Controlling weeds is, on average, the most severe problem associated with growing citrus organically (as reported by 15 growers answering the question). Thirteen of 15 growers rated weed control as either a large or severe problem. In particular, Brazilian pepper trees, Johnson grass, and vines are identified by growers as being difficult to control. Obtaining market information and finding buyers, packers and processors of organic citrus were the next highest rated problems. Labor costs, obtaining production information, soil fertility and nutrient sources, and recordkeeping and paperwork were also significant problems receiving mean scores greater than 1.

Six exiting growers that had been growing citrus organically, but gave up organic citrus within the last couple years were contacted to provide additional insight regarding obstacles to growth in the organic citrus sector. Two exiting growers indicated that unfavorable market conditions were primary reasons for giving up organic citrus. Another suggested that organic citrus was not profitable or financially feasible. One exiting grower said that he had difficulty managing a relatively small organic grove separately from large conventional groves, and that conventional chemicals were mistakenly sprayed on the organic grove by his workers. One grower said that stricter requirements for organic certification were a factor in his decision to give up organic citrus production, and another grower reported that personal illness was the main factor.

Alternative Land Uses

Upon giving up organic citrus, the land may be converted to a variety of alternative uses. Among the six exiting growers contacted, three said that they were selling the land for development, two said that they continue to grow citrus conventionally, and one said the land is maintained as her family's primary residential property.

Current organic citrus growers were also asked what they would do with their organic citrus land if they could not succeed meeting their minimum goals growing citrus organically. Of 16 growers who responded to this question and provided only one answer, seven (44%) said that they would sell or give up the lease on the land. Five (31%) said they would grow a different agricultural product, and four (25%) said they would grow citrus conventionally.

The high percentage of respondents indicating that selling the land would be the next best alternative is not surprising given current trends in Florida. First, returns from conventional citrus have been low and the economic outlook for conventional Florida citrus remains weak. Second, rapid residential development in Florida has increased land values and the pressure on agricultural land to be sold for housing.

Dissemination of Organic Knowledge

Current Information Sources

Growers were asked to name their two most helpful sources of organic citrus production information by category. Responses are listed in Table 6-16. Own trials and other growers were most frequently mentioned among the two most helpful sources of organic citrus production information.

Only 9 responses were obtained regarding growers' two most helpful sources of organic citrus marketing information. Results are listed in Table 6-17. "Individual customers, handlers, or brokers," followed by "own trial and error" were the most frequently mentioned sources of organic citrus marketing information. Results suggest that good organic citrus production and marketing information is not widely available to growers.

Table 6-16. Sources of organic citrus production information.

Sources of organic citrus production info	Number of mentions (21 respondents)
Own Trials	7
Other growers	6
Consultants	4
USDA Standards or OMRI list	4
Trade magazines, books, or websites	3
Old ways or family heritage	3
UF/IFAS Extension Agents	2
Certification Agencies	2
Input Suppliers	2
Conferences, seminars, or workshops	1

Table 6-17. Sources of organic citrus marketing information.

Sources of organic citrus marketing info	Number of mentions (9 respondents)
Individual customers, handlers, or brokers	5
Own trial and error	3
Other growers	1
Consultants	1

The University of Florida, IFAS, recently initiated on-farm and experiment station research on the use of cover crops and organic sprays to control weeds in organic citrus groves. Also, several extension documents relating to organic citrus in Florida were published recently. These information sources may be helpful to growers and others in the organic citrus industry.

Research Needs

Growers were asked an open-ended question: "In your opinion, what are the highest priority research needs for organic citrus production and marketing?" Multiple responses were recorded for each of the twenty growers responding to this question. Results are presented in Table 6-18. Weed management, soil fertility and nutrition, and market outlets/information were the most frequently cited research needs. More than one grower mentioned rootstock research, organic advertising and promotion, and soil or leaf sampling aids as important needs.

Table 6-18. Highest priority research needs

Research need	Number of mentions (20 respondents)
Weed management	10
Soil fertility and plant nutrition	5
Market outlet information	5
Rootstock research and development	3
Organic advertising and promotion	2
Soil or leaf sampling devices for growers	2
A device to check for pesticides	1
Water storage and excess salt removal	1
Additional organic-approved inputs	1
Pest management	1
Post-harvest handling	1
Comparison of organic vs. conventional in terms of impact on soil flora and fauna	1
Tighter inspection and control of fraud	1

Table 6-19. Additional concerns among organic citrus growers

Concern	Number of Mentions
Department of Citrus marketing constraints	3
Small farmer difficulties in production and marketing	2
International competition	2
Dominance of organic market by big companies	1
Grower share of final food dollar	1
Too many growers flooding the organic market	1
Few processors that buy organic fruit from other growers	1
Inability to sell transitional fruit	1
High cost of organic nitrogen sources relative to conventional	1
Organic growers are over interviewed and under served	1

Other concerns among organic citrus growers were noted during the interviews.

These concerns are summarized in Table 6-19. Prominent among these are Department of Citrus marketing constraints, production and marketing difficulties specific to small growers, and international competition.

Summary of Findings

Since 1993, when 568 acres of organic citrus acreage in Florida were documented (Swisher, Monaghan and Ferguson), organic citrus production has expanded considerably. The USDA-ERS estimates that organic citrus acreage in Florida jumped

from 2,296 acres in 1997 to 6,056 acres in 2001. Data provided by this survey and the FDACS organic registration program estimate current organic acreage at about 4,800 acres spread among thirty-one certified organic growers. The cause of the decline since 2001 is open to speculation. Estimates of transitional acreage due to become fully certified next season suggest that certified organic citrus land will increase to approximately 6,000 acres in 2004-05.

The fresh market is of greater importance for Florida's organic citrus sector than it is for Florida's conventional citrus. Whereas about one-quarter of conventional citrus acreage in Florida is intended for the fresh market, approximately one-half of Florida's organic citrus acreage is intended for the fresh market. Grapefruit and tangerines represent a higher portion of the organic citrus crop than they do for the conventional citrus crop in Florida.

Primary market outlets for fresh organic citrus are specialty supermarkets, natural food stores, and supermarket chains in urban centers of the Northeast and Midwest. Organic orange and grapefruit juice are sold nationwide at the same retail outlets. Both fresh citrus and juice are exported to Europe and Japan as well.

Growers report significant organic price premiums typically ranging from 20% to 100% above the conventional on-tree or delivered-in price. A few growers, however, report difficulty finding adequate markets for their crop and complain about the small number of packers and processors that buy fruit from independent growers. Eight certified organic packinghouses and five certified organic processing plants were identified as active during the first half of the 2003-04 season.

A diverse group, organic citrus growers and groves vary widely in terms of their characteristics and individual circumstances. Farm size, ownership vs. lease of land, market connections, integration with conventional citrus or other agricultural activities, business structure, input intensity and production costs, specific production practices, owner involvement with grove care, and reliance on off-farm employment serve to differentiate organic growers.

Out of thirty-five growers who were certified organic in either the 2002-03 or 2003-04 seasons, fourteen (40%) had organic citrus groves of 25 acres or less. Two growers owned or leased organic citrus groves totaling more than 1,000 acres. The mean acreage of a certified entity's citrus groves is 148 acres, and the median is 63 acres.

Five different types of organic citrus operations are described in this report. More generally, organic citrus growers can be divided by the intensity and cost of their grove care practices. One segment of growers manages the groves intensively to support good yields over the long-run. Another segment of growers invests in minimal grove care. Intensively managed groves have per acre costs that tend to be somewhat higher than conventional production costs. These organic groves obtain yields that are similar to, or in a few cases higher than, average conventional yields. Low input and low cost organic citrus operations typically obtain yields that are significantly lower than average conventional yields.

Specific grove care practices and reported yields vary substantially. Compared to conventional production, organic grove care typically requires higher costs for weed management and nutrient management, but lower costs for insect and other pest control. Human labor and machine time employed to control weeds is a major cost for organic

growers. Organic production tends to be more labor intensive, but avoids the use of synthetic inputs. A majority of organic citrus growers use poultry manure and fish emulsion as primary nutrient sources, depend on mechanical mowing, hand weeding and hoeing, and mechanical disking to control weeds, and do not rely on anything other than fish emulsion for insect control.

Gross margins are highest for the more intensively managed organic groves that obtain yields similar to or higher than average conventional yields. Hypothetical budgets for medium to high cost (and medium to high input intensity) organic groves suggest that gross margins can be significantly higher than conventional gross margins. Gross margin, however, does not include certification costs, additional managerial costs, and other fixed costs that may be associated with organic production. Also, the higher gross margin is dependent upon an organic price premium.

Growers report adopting certified organic production systems for a variety of reasons. Significant factors reported to be important include profitability, environmental or health concerns, and environmental liability risk. Financial incentives are paramount for most growers. The organic price premium is a crucial factor creating a financial incentive. Although an important segment of organic growers utilizes a low cost production system, most organic growers have grove care expenses similar to or higher than conventional expenses.

Weed control stands out as the most difficult challenge facing organic citrus growers. Obtaining market information and finding buyers, packers, and processors for organic fruit are large problems for some organic growers. Labor costs, soil fertility

under organic management, obtaining production information, and recordkeeping and paperwork present additional challenges for organic growers.

Conventional citrus, organic citrus, and selling land for development are three competing land uses in many areas. Half of the exiting growers sampled said that they are selling their land for development. Forty-four percent of current organic respondents said that they would sell or give up the lease on their land, if they could not succeed meeting their minimum goals growing citrus organically.

Organic growers rely heavily on their own trials and other growers for information on organic citrus production. Individual customers, intermediate handlers or brokers are the primary sources of market information.

Consistent with the greatest difficulties expressed by organic growers, weed control is most frequently mentioned as a high priority research need. Market research and research on soil fertility and plant nutrition under organic management are frequently mentioned needs as well. Other research needs reported by growers include rootstock research, improved support for soil and leaf sampling, and advertising and promotion.

Conclusions and Avenues for Further Research

Organic citrus acreage appears to be on the rise once again, despite an apparent dip in certified acreage between 2001 and 2002. New growers are becoming certified this year and next. In addition, some current organic growers are expanding their certified acreage.

Although increasing supply without a concurrent increase in demand could erode the organic price premium, that possibility does not appear likely in the short-run. Most growers and handlers report that demand has been strong and seems to be increasing. Growers have reported receiving five- to ten-year contracts from processors for their

fruit. These long-term contracts suggest that marketers have confidence in the continued strength of demand for organic citrus.

Some growers have established grove care systems and found market outlets that appear to be economically viable for the long-term. Others utilize the organic option as a short-term bridge between alternative land uses, especially between conventional citrus and conversion of land to residential development. Reflecting in part the weak economic outlook for conventional citrus in Florida and the pressure from development, organic citrus growers are more likely to sell their land for development than revert to conventional citrus production. These findings suggest that as long as it continues to be economically viable, organic citrus presents an alternative that can slow the rate of conversion of agricultural land to housing developments in Florida.

Organic citrus production is not without pitfalls however. The wide variety of production practices reflects considerable experimentation and a lack of consensus regarding the most efficient organic grove care practices. A few growers report yields above typical conventional yields, but most report yields that are somewhat lower than conventional. Some growers describe a learning curve, reporting that they struggled to find an organic system that maintained the health of their trees and satisfactory yields during the early years of transitioning to organic management. The variety of production practices and difficulties that some growers have faced highlight the fact that good information on organic citrus production is not widely available. Own trial and error is mentioned more frequently than any other source of organic production information.

The University of Florida has published extension bulletins on organic citrus and is engaging in research on organic weed control methods. This research, as well as research

on organic nutrient management and other needs expressed by growers, could bring substantial benefits to growers.

Additional market research could help growers and handlers identify potential new market outlets or adjust their marketing practices. Advertising and promotion aimed at consumers could boost demand for organic citrus. Research on the benefits of organic citrus production, including consumer benefits such as lower pesticide residues and public benefits relating to biodiversity or water quality could help stimulate demand for organic citrus. Research and education about impacts on the environment and human health, including farm worker health, could increase incentives for growers to adopt organic systems.

Long-term sustainability and growth of organic citrus production depend on a variety of factors. Unless effective cover cropping systems, organic sprays, or other weed control methods are found, organic citrus production will remain highly dependent on labor and machine inputs to control weeds. As labor and fuel costs rise, this is a cause of some concern. Likewise, organic citrus production is dependent on organic nutrient sources, such as poultry manure, urban plant debris, organic bulk blend fertilizers, and fish emulsion. As organic production increases and input demand rises, the availability and cost of these inputs will become more critical. Research on the potential of expanding supply of organic inputs and on new organic input sources would provide insight regarding the long-term sustainability of organic citrus production.

CHAPTER 7 CONCLUSION

In this dissertation, we analyzed the efficacy of voluntary environmental labeling programs using economic theory and methods. In Chapters 2 and 3, we reviewed literature on economic theories of the consumer and producer and presented models of consumer and producer decisions in light of environmental certification and labeling. In Chapter 4 we introduced two models that provide insight regarding the potential effects of eco-labeling on production, land-use and the environment under different market conditions. In Chapter 5, we assessed the efficacy of voluntary labeling as a possible replacement for government-mandated environmental policies. An EMP label being developed for ornamental plants is used as an example for the theoretical analysis. Finally, results of a 2003-04 study of the organic citrus sector in Florida are presented in Chapter 6.

Our consumer model provides support for the intuitive result that eco-labeling causes demand for the environmentally differentiated product to rise and causes demand for the undifferentiated product to fall. Also, we identify non-price incentives associated with environmental certification and labeling programs that can increase “green” supply and reduce conventional supply at constant prices.

These initial impacts of eco-labeling can lead to different effects on production, land-use and the environment, depending on specific conditions. We identified several relevant conditions, including the relative environmental impacts of competing land-uses, whether excess “green” supply is sold on the undifferentiated market, the relative

magnitudes of demand and supply shifts, and own- and cross-price responses of demand and supply. If alternative land-uses are environmentally inferior to either “green” or conventional production, eco-labeling is most likely to be effective at improving environmental quality. Under this condition, any impact that increases producer returns will tend to pull land out of alternative uses (or slow conversion to alternative uses) with positive environmental consequences. In particular, when eco-labeling increases total farm-gate demand (after accounting for any changes in marketing costs) or reduces costs of “green” production, it generates positive environmental effects through shifts in land-use incentives.

Under the condition that alternative land-uses are environmentally superior to either conventional or “green” production, eco-labeling programs are generally less effective at protecting the environment and can lead to further environmental harm. In this case, reduction in demand for the undifferentiated product and nonprice incentives that induce conventional producers to adopt certified practices can still lead to positive environmental benefits. Increases in demand for the environmentally differentiated product, without offsetting decreases in demand for the undifferentiated product can lead to a rise in conventional production and more environmental harm. This unintended consequence is most likely to occur when excess “green” supply is sold on the undifferentiated market.

The potential for unintended consequences, and its limited effectiveness at protecting the environment under certain market conditions, reduce the efficacy of environmental labeling as a policy alternative. Even if unintended consequences are avoided, other factors limit the efficacy of environmental labeling relative to government-

mandated environmental policies. Our analysis demonstrates that eco-labels for public attributes are not likely to lead to a Pareto efficient outcome. They do not overcome the externalities and free-rider problem that lead to environmental degradation beyond what is socially optimal, in a Pareto sense. Additional costs for identity preservation and marketing, often associated with environmental labeling, are not required for government tax or subsidy schemes linked to environmental management practices. Furthermore, well-designed environmental tax or subsidy programs are more directly targeted and can avoid the unintended consequences that can result from consumer-generated incentives associated with eco-labeling. Finally, voluntary environmental labeling is based on the premise that producers have a right to pollute and that individual consumers must pay for environmental protection. This premise has implications for both equity and efficiency. Producers would favor voluntary labeling or a subsidy program over an environmental tax. Consumer and taxpayer receptiveness to voluntary labeling vs. mandatory policies probably depends on equity perceptions and institutional preferences.

An empirical evaluation of the efficacy of the IPM or EMP label being developed for ornamental plants in Florida should consider the factors identified in the preceding theoretical analysis. In particular, an assessment of the primary competing land-uses and their relative environmental impacts would be important. If ornamental plant nurseries compete primarily with residential development for land and water resources, as in the citrus sector, one would expect that either uncertified or certified nursery production might generate less negative environmental impacts. In that case, any labeling program that increases demand for Florida-grown ornamental plants or creates price and nonprice incentives for nursery growers to adopt EMPs would generate environmental benefits.

If the benefits from EMP labeled plants are perceived by consumers to be purely public in nature (i.e., pertaining only to broad environmental impacts), consumer willingness to pay premiums for the label may be rather limited. Consumer studies could identify specific attributes (environmental and otherwise) to which consumers are most receptive. A certification standard that combines environmental attributes with private characteristics that consumers value is most likely to be effective at generating increases in demand and price premiums.

Data on existing use of EMP practices in the nursery industry, existing markets for environmentally differentiated plants, and the potential demand for EMP labeled plants would provide valuable insight about the ultimate effect on production. Additionally, survey research could assess the receptiveness of nursery growers to price and nonprice incentives pertaining to EMP adoption, certification, and labeling.

The case study of the Florida organic citrus sector generates several interesting conclusions. Organic growers are a very heterogeneous group, making it difficult to classify them and model their behavior as a group. Although price incentives are most important on average, nonprice incentives are also important factors in the decision of some growers to obtain organic certification. Specifically, a desire to reduce the perceived risk of environmental liability, and personal beliefs and concerns about the environment and human health were among the reasons behind organic adoption decisions. One striking result, in light of the sector model analysis, is the prominence of housing developments as the next best alternative competing land-use. Half of exiting growers surveyed stated that they have sold or are in the process of selling their land for development. More than forty percent of current organic citrus growers responding

stated that they would sell their land if they could not succeed in organic citrus. Most of them stated explicitly that the land would be used for housing developments. Another conclusion from our study is that there is little consensus on the best production methods for organic citrus, and growers describe a lack of helpful information on organic citrus production.

Research and extension activities and other policies that reduce costs and make organic citrus production and marketing more efficient could benefit the sector. Since the major competing land use is residential housing, improving the economic viability of organic citrus through measures to stimulate demand or supply can slow the conversion of land to development. Assuming that housing developments and urban sprawl have environmental effects worse than any associated with either organic or conventional citrus production, policies that improve the profitability of organic citrus production can generate environmental benefits.

Consumers purchase organic products for various reasons, including both private and public attributes. Although organic demand continues to grow, it is not likely that the organic label can be relied on to protect the environment in agricultural regions. If environmental protection is the policy objective, well-designed environmental tax and subsidy incentives would be more effective.

In the absence of effective government-mandated environmental policies and under certain market conditions, voluntary environmental labeling can create incentives that reduce the use of harmful production practices. Eco-labels that represent pure public attributes are not likely to generate much consumer response however. Eco-labels that combine public and private attributes, such as the organic label, will be most successful at

stimulating demand. Even when eco-labels are successful at generating considerable demand, unintended consequences under certain market conditions reduce their environmental effectiveness. Also, various factors limit the Pareto efficiency potential and cost-effectiveness of voluntary labeling relative to policy alternatives. Furthermore, some individuals may object to a general policy of voluntary labeling on equity grounds. For these reasons we caution against embracing voluntary environmental certification and labeling programs as a policy alternative, especially under market conditions that render them ineffective at protecting the environment.

APPENDIX A MATHEMATICAL APPENDIX FOR TWO-PRODUCT, PARTIAL-EQUILIBRIUM MODEL

Assuming that the supply and demand functions have continuous partial derivatives with respect to all variables and parameters and that the endogenous variable Jacobian determinant is nonzero, the endogenous variables (P and Q) may be treated as implicit functions of the exogenous variables (ρ and ν). This is a version of the implicit function theorem (Chiang). Totally differentiating the equilibrium identities produces a linear system of equations, and ratios of differentials (endogenous variables with respect to the exogenous variable) can be obtained and treated as partial derivatives (Chiang). Given the above assumptions, a unique solution exists for each of these partial derivatives (Chiang).

Totally differentiating the six identities in Eq. 4-1 with respect to six endogenous variables and the two exogenous variables, ρ and ν , produces the following system of linear equations:

$$\begin{aligned}
 & S_{gg} dP_g + S_{gc} dP_c - dQ_g = -\partial S_g / \partial \nu d\nu \\
 & S_{cc} dP_c + S_{cg} dP_g - dQ_c = -\partial S_c / \partial \nu d\nu \\
 (A-1) \quad & D_{ee} dP_e + D_{eu} dP_u - dQ_g = -\partial D_e / \partial \rho d\rho \\
 & D_{uu} dP_u + D_{ue} dP_e - dQ_c = -\partial D_u / \partial \rho d\rho \\
 & dP_g - dP_e = -\partial M_e / \partial \rho d\rho \\
 & dP_c - dP_u = 0
 \end{aligned}$$

S_{ij} represents the partial derivative of supply quantity i with respect to price j . D_{ij} represents the partial derivative of demand quantity i with respect to price j .

First, considering the impact of a change in ρ only and setting $d\nu = 0$, each equation can be divided by the exogenous differential $d\rho$. The resulting equation system can be expressed in matrix form as

$$(A-2) \quad \begin{bmatrix} 0 & 0 & S_{gg} & S_{gc} & -1 & 0 \\ 0 & 0 & S_{cg} & S_{cc} & 0 & -1 \\ D_{ee} & D_{eu} & 0 & 0 & -1 & 0 \\ D_{ue} & D_{uu} & 0 & 0 & 0 & -1 \\ -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} dP_e/d\rho \\ dP_u/d\rho \\ dP_g/d\rho \\ dP_c/d\rho \\ dQ_g/d\rho \\ dQ_c/d\rho \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -\partial D_e/\partial\rho \\ -\partial D_u/\partial\rho \\ -M_{el} \\ 0 \end{bmatrix}$$

Isolating the effects of changes in ν only, we set $d\rho = 0$, divide each equation by $d\nu$, and express the system in matrix form as

$$(A-3) \quad \begin{bmatrix} 0 & 0 & S_{gg} & S_{gc} & -1 & 0 \\ 0 & 0 & S_{cg} & S_{cc} & 0 & -1 \\ D_{ee} & D_{eu} & 0 & 0 & -1 & 0 \\ D_{ue} & D_{uu} & 0 & 0 & 0 & -1 \\ -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} dP_e/d\nu \\ dP_u/d\nu \\ dP_g/d\nu \\ dP_c/d\nu \\ dQ_g/d\nu \\ dQ_c/d\nu \end{bmatrix} = \begin{bmatrix} -\partial S_g/\partial\nu \\ -\partial S_c/\partial\nu \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

For each of the two systems of matrix equations, the endogenous variable Jacobian determinant is: $|J| = (S_{gg} - D_{ee})(S_{cc} - D_{uu}) - (S_{gc} - D_{eu})(S_{cg} - D_{ue})$. If both goods are normal and have well-behaved supply and demand functions, the Jacobian determinant is positive. This result follows from the negative semi-definiteness of the substitution matrix and the assumption that own-price effects outweigh cross-price effects.

Using Cramer's rule, we obtain the solutions to the comparative static derivatives of interest. The derivatives representing the direction and rate of impact on supply quantities as the parameters ρ and ν change are

$$\begin{aligned}
& \frac{[S_{cg}D_{eu} - S_{cc}D_{ee} + S_{gg}S_{cc} - S_{gc}S_{cg}]\partial D_u/\partial \rho}{|J|} \\
(A-4) \quad \frac{dQ_c}{d\rho} = & + \frac{[S_{cc}D_{ue} - S_{cg}D_{uu}]\partial D_e/\partial \rho}{|J|} \\
& + \frac{[D_{ue}(S_{gg}S_{cc} - S_{gc}S_{cg}) - S_{cg}(D_{ee}D_{uu} - D_{eu}D_{ue})]\partial M_e/\partial \rho}{|J|} \\
(A-5) \quad \frac{dQ_c}{d\nu} = & \frac{[(D_{ee}D_{uu} - D_{eu}D_{ue}) + (S_{gc}D_{ue} - S_{gg}D_{uu})]\partial S_c/\partial \nu + [S_{cg}D_{uu} - S_{cc}D_{ue}]\partial S_g/\partial \nu}{|J|} \\
& \frac{[S_{gc}D_{ue} - S_{gg}D_{uu} + S_{gg}S_{cc} - S_{gc}S_{cg}]\partial D_e/\partial \rho}{|J|} \\
(A-6) \quad \frac{dQ_g}{d\rho} = & + \frac{[S_{gg}D_{eu} - S_{gc}D_{ee}]\partial D_u/\partial \rho}{|J|} \\
& + \frac{[D_{ee}(S_{gg}S_{cc} - S_{gc}S_{cg}) + S_{gg}(D_{eu}D_{ue} - D_{ee}D_{uu})]\partial M_e/\partial \rho}{|J|} \\
(A-7) \quad \frac{dQ_g}{d\nu} = & \frac{[(D_{ee}D_{uu} - D_{eu}D_{ue}) + (S_{cg}D_{eu} - S_{cc}D_{ee})]\partial S_g/\partial \nu + [S_{gc}D_{ee} - S_{gg}D_{eu}]\partial S_c/\partial \nu}{|J|}
\end{aligned}$$

Next we consider the second pre-labeling scenario, in which a portion of green product is sold on the undifferentiated market. Totally differentiating the six identities in Eq. 4-4 with respect to the six endogenous variables and two exogenous variables produces the following system of linear equations:

$$\begin{aligned}
& (S_{gg} + S_{cg})dP_g + (S_{cc} + S_{gc})dP_c - (D_{ee} + D_{ue})dP_e - (D_{uu} + D_{eu})dP_u \\
& = (\partial D_e/\partial \rho + \partial D_u/\partial \rho)d\rho - (\partial S_g/\partial \nu + \partial S_c/\partial \nu)d\nu \\
& S_{gg}dP_g + S_{gc}dP_c - dQ_g = -\partial S_g/\partial \nu d\nu \\
(A-8) \quad & S_{cc}dP_c + S_{cg}dP_g - dQ_c = -\partial S_c/\partial \nu d\nu \\
& dP_g - dP_e = -\partial M_e/\partial \rho d\rho \\
& dP_c - dP_u = 0 \\
& dP_g - dP_u = 0
\end{aligned}$$

Suppressing the exogenous variable v (setting $dv = 0$), dividing each equation by $d\rho$, and expressing the system of equations in matrix form produces

$$(A-9) \begin{bmatrix} -(D_{ee}+D_{uu}) & -(D_{uu}+D_{eu}) & (S_{gg}+S_{cg}) & (S_{cc}+S_{gc}) & 0 & 0 \\ 0 & 0 & S_{gg} & S_{gc} & -1 & 0 \\ 0 & 0 & S_{cg} & S_{cc} & 0 & -1 \\ -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dP_e/d\rho \\ dP_u/d\rho \\ dP_g/d\rho \\ dP_c/d\rho \\ dQ_e/d\rho \\ dQ_c/d\rho \end{bmatrix} = \begin{bmatrix} \partial D_e/\partial\rho + \partial D_u/\partial\rho \\ 0 \\ 0 \\ -\partial M_e/\partial\rho \\ 0 \\ 0 \end{bmatrix}$$

Setting $d\rho = 0$, dividing each equation by dv , and expressing the system in matrix form produces

$$(A-10) \begin{bmatrix} -(D_{ee}+D_{uu}) & -(D_{uu}+D_{eu}) & (S_{gg}+S_{cg}) & (S_{cc}+S_{gc}) & 0 & 0 \\ 0 & 0 & S_{gg} & S_{gc} & -1 & 0 \\ 0 & 0 & S_{cg} & S_{cc} & 0 & -1 \\ -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dP_e/dv \\ dP_u/dv \\ dP_g/dv \\ dP_c/dv \\ dQ_e/dv \\ dQ_c/dv \end{bmatrix} = \begin{bmatrix} -(\partial S_g/\partial v + \partial S_c/\partial v) \\ -\partial S_g/\partial v \\ -\partial S_c/\partial v \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

The endogenous variable Jacobian determinant in this case is:

$$|J| = (-1)[(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})]. \text{ The sign of this}$$

determinant is unambiguously negative, assuming own-price effects outweigh cross-price effects. The solutions to the comparative static derivatives representing the rate of change in quantities supplied with respect to changes in the exogenous variables ρ and v are obtained using Cramer's rule. Multiplying the numerators and denominators by negative one, these derivatives are

$$(A-11) \frac{dQ_c}{d\rho} = \frac{[S_{cc} + S_{cg}](\partial D_e/\partial\rho + \partial D_u/\partial\rho) + [(D_{ee} + D_{ue})(S_{cc} + S_{cg})]\partial M_e/\partial\rho}{(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})}$$

$$(A-12) \frac{dQ_c}{dv} = \partial S_c/\partial v + \frac{[-(S_{cc} + S_{cg})](\partial S_g/\partial v + \partial S_c/\partial v)}{(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})}$$

$$(A-13) \quad \frac{dQ_g}{d\rho} = \frac{[S_{gg} + S_{gc}](\partial D_e / \partial \rho + \partial D_u / \partial \rho) + [(D_{ee} + D_{ue})(S_{gg} + S_{gc})] \partial M_e / \partial \rho}{(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})}$$

$$(A-14) \quad \frac{dQ_g}{d\nu} = \partial S_g / \partial \nu + \frac{[-(S_{gg} + S_{gc})](\partial S_g / \partial \nu + \partial S_c / \partial \nu)}{(S_{gg} + S_{gc}) + (S_{cc} + S_{cg}) - (D_{ee} + D_{eu}) - (D_{uu} + D_{ue})}.$$

APPENDIX B

GAMS PROGRAM FOR PRICE-ENDOGENOUS MODEL

SETS

CP curve parameters
 /INTERCEPT,SLOPE,SHIFTER/
 J demand curves
 /COFF1,ENV1,COFF2,LV/
 I production cost curves
 /CNV,GRN/
 M market
 /ONE,TWO/;

TABLE

D(J,CP) demand curve parameters

	INTERCEPT	SLOPE	SHIFTER
COFF1	16	-0.4	1000000
ENV1	9	-2.5	500000
COFF2	14.4	-1.6	0
LV	1120	-15	1000;

TABLE

S(I,CP) production cost curve parameters

	INTERCEPT	SLOPE	SHIFTER
CNV	600	6	1000
GRN	700	10	1000;

PARAMETERS

TC(M) transport and marketing cost
 /ONE 500000, TWO 1000000/
 LC(M) labeling cost
 /ONE 10000, TWO 10000/
 L(M) eco-label introduced or not
 /ONE 1, TWO 0/
 YD(I) yield per acre
 /CNV 0.35, GRN 0.3/;

SCALAR

XT total available land in region in thousands of acres
 /100/;

VARIABLES

X(I) acres in each land use
 Y(I) total coffee production from each land use
 YGL(M) labeled green coffee going to each market
 YGU unlabeled green coffee
 Z(J) final demand quantities
 OBJ quasi welfare function;

POSITIVE VARIABLE X;
 POSITIVE VARIABLE Y;
 POSITIVE VARIABLE YGL;
 POSITIVE VARIABLE YGU;
 POSITIVE VARIABLE Z;

EQUATIONS

WELFARE quasi welfare function
 LAND land constraint
 YIELD(I) yield constraint
 GREEN green yield constraint
 COFFEE coffee demand constraint in market one
 ECO ecolabel demand constraint in market one
 TWO labeled coffee demand in market two;

WELFARE..

OBJ=E=SUM(J,D(J,"SHIFTER")*(D(J,"INTERCEPT")*Z(J)+0.5*D(J,"SLOPE")*Z(J)*
 2))-SUM(I,S(I,"SHIFTER")(S(I,"INTERCEPT")*X(I)+0.5*S(I,"SLOPE")*X(I)**2))-
 TC("ONE")*Z("COFF1")-TC("TWO")*Z("COFF2")-SUM(M,L(M)*LC(M)*YGL(M));
 LAND.. SUM(I,X(I))+Z("LV")=L=XT;
 YIELD(I).. Y(I)-(YD(I)*X(I))=L=0;
 GREEN.. YGU+SUM(M,YGL(M))-Y("GRN")=L=0;
 COFFEE.. Z("COFF1")-YGU-YGL("ONE")-Y("CNV")=L=0;
 ECO.. Z("ENV1")-YGL("ONE")=L=0;
 TWO.. Z("COFF2")-YGL("TWO")=L=0;

MODEL ECOLABEL1 /ALL/;

SOLVE ECOLABEL1 USING NLP MAXIMIZING OBJ;

DISPLAY X.L,X.M,Z.L,Z.M;

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BIOGRAPHICAL SKETCH

Kevin Athearn was born in Philadelphia, PA. After moving to New Jersey with his family, he attended Northern Burlington County Regional High School, and spent a year as an exchange student at Gymnasium Syke in Syke, Germany. In 1991, Kevin received a B.A. degree in international relations from Ursinus College in Collegeville, PA. His undergraduate studies included a semester abroad at the Institute for European Studies in Vienna, Austria.

After working for several years in the international shipping industry as a foreign freight forwarder, Kevin began a 7-year career as a graduate student at the University of Florida. He received an M.A. degree in Latin American studies, and now a Ph.D. in food and resource economics. Kevin plans to move to Maine with his wife, Lisa, and continue work on natural resource economics.

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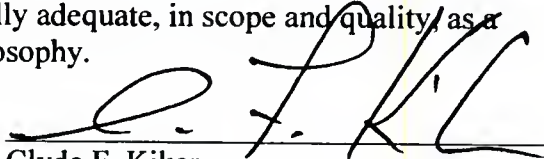
James A. Sterns, Chair
Assistant Professor of Food and Resource
Economics

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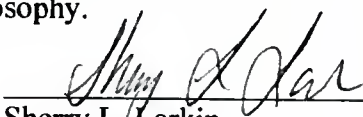
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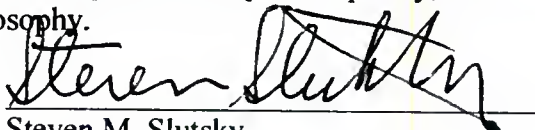
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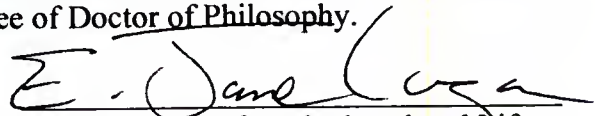
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This dissertation was submitted to the Graduate Faculty of the College of Agricultural and Life Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 2004

A handwritten signature in black ink, appearing to read "E. Daniel Lugo", written over a horizontal line.

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Sciences

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